2018

AP CollegeBoard

AP Environmental Science

Sample Student Reponses and Scoring Notes

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2018 AP® ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

ENVIRONMENTAL SCIENCE

SECTION II

Time—1 hour and 30 minutes

4 Questions

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times **May 1, 2018**

GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a "shining beacon" of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

(a) The students want to reduce the school's carbon footprint.

(i) **Define** carbon footprint.

(ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.

(iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.

(b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.

(c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.

(d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.

(e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

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2018 SCORING GUIDELINES — Version 1.0

Question 1

Read the following article from the *Fremont Daily Times* and answer the questions that follow.

(a) The students want to reduce the school's carbon footprint.

(i) **Define** carbon footprint.

(1 point for correct definition of carbon footprint)

- The amount of carbon dioxide and/or other carbon compounds released to the environment by a product, process, or activity
- A measurement of the amount of carbon released by human activities

(ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.

(1 point for correct identification of a way the school's heating system is adding to its carbon footprint)

- The burning/combustion of fossil fuels releases carbon dioxide
- The incomplete combustion of fossil fuels releases carbon monoxide

(iii) **Describe** one realistic way to reduce the contributions of the heating system to the school's carbon footprint

(1 point for correct description of realistic way to reduce contribution of heating system)

- Switch to renewables (solar, wind, etc.)/switch to a more efficient fossil fuel (natural gas, propane)/switch to a provider that uses nuclear energy
- Decrease the temperature/thermostat in the school during the winter/program thermostat to lower energy consumption during certain times
- Purchase credits through environmental agencies for carbon-offsetting projects
- Increase insulation or implement other efficiency/design methods to reduce energy demand (green roof, double paned glass, south-facing windows for passive solar heating, change air filters, etc.)

(b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.

(2 points; 1 point for each correct identification of an environmental benefit of a green roof)

- Insulation/reduced use of fossil fuels for heating and/or cooling
- Habitat for wildlife and/or plants/increases biodiversity
- Area to grow crops/production of food locally
- Reduction in the number of heat islands in the environment/urban heat island mitigation
- Photosynthesis/carbon capture/CO2 storage/oxygen release
- Storm water treatment/runoff reduction
- Filters particulates, VOCs, O3 from air

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(c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.

(2 points; 1 point for each correct description of a practice that decreases the environmental impact of the school)

- Offer more vegetarian options/serve fewer animal products, etc. to reduce impact from meat production
- Use some locally sourced food to reduce transportation
- Grow food at the school to reduce transportation
- Compost food waste to reduce the amount disposed in landfills
- Donate leftover food to reduce food waste
- Use energy-friendly practices (LED lighting, serve more cold-cut sandwiches, etc.) to decrease energy use
- Purchase bulk packaged items to reduce material waste
- Use recyclable food containers/don't use disposable straws/food containers/trays to reduce material waste
- Install a water fountain/stop selling single serving water bottles to reduce material waste
- Use re-useable take out containers/offer savings or credit for reusing containers to reduce material waste
- Allow students to choose appropriate portions to reduce food waste
- Purchase organic foods to reduce pesticide use
- Use gray water to irrigate landscaping to reduce potable water use

(d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.

(2 points; 1 point for each correct discussion of benefits of using native plants)

- Native plants require less pesticides because they are better adapted to their environment
- Native plants require less fertilizer because they are better adapted to their environment
- Native plants require less irrigation water because they are better adapted to their environment
- Native plants increase biodiversity by providing native habitat areas
- Native plants support native food webs/native food production by providing native habitat areas
- Native plants reduce the amount of land available for the establishment/spread of invasive species
- Native plants save the school money by requiring less water/fertilizer/pesticides/upkeep

(e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

(1 point for correct discussion of benefits of using flooring made of plant material)

- Plant-based material is more easily compostable/is biodegradable/can be reused/repurposed unlike carpet
- Plant-based material is from a renewable resource making it more sustainable than carpet
- Plant-based material is a carbon sink/reservoir, so growing plant materials removes CO_2 from the atmosphere unlike carpets
- Plant-based materials require less fossil fuels/toxic chemicals for production than synthetic fibers found in carpets
- Plant-based materials produce less indoor pollutants (off-gas pollutants/VOCs/release toxins) than carpet
- Plant-based materials harbor fewer pathogenic vectors/diseases/allergens (fleas, ticks, dust mites, mold spores, etc.) than carpets
- Plant-based material when cultivated provides habitat for native species

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PAGE FOR ANSWERING QUESTION 1

a(i) - A carbon footprint is a measure of the amount of carbon dioxide and ~~out~~ other carbon compounds released by various human activities

a(ii) - The heating system of the school is adding to the carbon footprint because it relies on burning fossil fuels. The burning of fossil fuels releases CO_2 and other compounds into the air which adds to the carbon footprint.

a(iii) - One realistic way to reduce the heating system's footprint is to install better insulation. By installing better insulation less heat is required to keep a room at a warmer temperature. Therefore less fuel is used to heat and reduces the carbon footprint.

b. - One environmental impact of a green roof is that it reduces the need for cooling and heating because of its insulative properties. Another impact would be that it will increase biodiversity in the area and provide shelter and food for wild birds.

c. - The cafeteria could source all its food from within 50 miles of its production to reduce the amount of CO_2 released by shipping. The Cafeteria could also utilize reusable ~~plates~~ plates and silverware to reduce the trash waste from the school.

d - One benefit to using native plants would be that it would not need fertilizers or increased irrigation because it is designed ~~to~~ to thrive in the existing environmental conditions. Another benefit to using native plants is that it gives shelter and food to wildlife such as deer and birds which helps with biodiversity.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

e- An environmental benefit to using wooden paintbrushes made of bamboo or cork is that it is a renewable resource. The benefit is that the material is made of fast growing plants which are easier to regrow which makes it better than synthetic carpets because the synthetics are made of petroleum products which are not renewable.

PAGE FOR ANSWERING QUESTION 1

a i. A carbon footprint is the measure of the amount of carbon compounds produced by all human activity in an area, including electricity generation, transportation, food, etc.

ii. The school's heating system is likely adding to its carbon footprint because when fossil fuel is combusted to heat the building, it will release carbon dioxide into the atmosphere, increasing the carbon footprint.

iii. One realistic way to reduce the heating system's contribution to the carbon footprint is to utilize the heating system less, so that the school will keep its thermostat to a lower temperature and instead encourage students to wear thicker jackets indoors. Since there will be less combustion of fossil fuels, there will be less carbon dioxide released into the atmosphere.

b. One environmental benefit of a living green roof is that the plants on the roof produce oxygen, which adds to the overall oxygen levels in the atmosphere. Another environmental benefit is that the green roof plants may provide habitats for numerous animal species in the area, promoting biodiversity.

c. The cafeteria of Fremont High School can decrease environmental impacts by only using locally grown produce to reduce the carbon dioxide produced during transportation of the vegetables. The cafeteria can also serve more grains and vegetables than meat because less resources (such as land and water) are used to produce grains and vegetables than the same amount of livestock. This will

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conserve these resources of land and water.

d. One benefit of using native plants for landscaping is that the native plants provide natural habitats or food for local species of insects and animals. Another benefit of using native plants for landscaping is that they can enrich the soil with nutrients because they are adapted to the local soil — they will not drain the soil of nutrients in this case.

e. One environmental benefit of using plant material instead of synthetic material for flooring is that plant material is biodegradable, which means it will eventually decompose and return nutrients to the natural world once it is thrown away. Synthetic fibers, on the other hand, are persistent, so they will ~~those~~ remain as trash for a long time, potentially harming animals that may ingest it.

PAGE FOR ANSWERING QUESTION 1

a) Carbon footprint is the measure of the amount of carbon compounds, such as carbon dioxide, that are released by human activities. The school's heating system is supplied by fossil fuel combustion, which releases carbon dioxide emissions when burning fossil fuels; this adds to the school's carbon footprint. The school can reduce the contribution of the heating system to the school's carbon footprint by utilizing other methods to obtain heat that don't release as much carbon dioxide emissions. An example would be replacing the fossil fuel combustion system with a renewable energy source, such as wind — through a wind turbine, wind turns turbines that then generate electricity which can be used as a heating source. Using wind has a significantly smaller release of carbon compounds compared to fossil fuel combustion, thus reducing the school's carbon footprint.

b) A living green roof provides a habitat for organisms. For example, the green roof can contain species of plants that attract insects such as bees who can pollinate and thrive/survive from the plants on the roof. Another benefit of a living green roof is that there would be more photosynthesizing plants removing carbon dioxide from the atmosphere — this would

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help to reduce the amount of greenhouse gases (carbon dioxide) in the atmosphere.

c) The cafeteria's food service can rely on serving food that belongs on lower trophic levels to help decrease environmental impacts of the school. By serving food on these lower levels, there is less energy being put into producing the food and less resources needed to grow the food (serving food on higher trophic levels - such as cattle - require more resources like water and crops in order to feed and sustain that cattle). Another practice would be for the school to rely on organic food that did not use fertilizers or pesticides in its production process. This would reduce the amount of persistant pesticides that accumulate in the environment or fertilizer nutrients that runoff from farms producing the food (the runoff can impact the environment by contaminating surface water sources).

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

d) Using native plants are beneficial because they provide a habitat for naturally occuring organisms in that area that are used to those plants. It provides an ecosystem for insects that are naturally living in that area. They are also beneficial because since native plants have native predators, their population sizes will not go beyond its capacity or to a level where it can harm the habitat.

e) Flooring made of plant material is more environmentally beneficial because in order to create synthetic fibers for carpeting, chemicals/toxins are used. These toxins can then be released into the environment and damage habitats. Producing plant material flooring uses less of these chemicals in the process, being more environmentally safe.

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PAGE FOR ANSWERING QUESTION 1

(a)(i) Carbon footprint is the measure of the amount of CO_2 and other carbon compounds released by different human activities.

(ii) The school's heating system burns fossil fuels which release carbon dioxide and methane, contributors to carbon footprints.

(iii) The school can replace their heating system with solar panels, a renewable energy source that does not release any carbon emissions.

(b) The living green roof would provide more plants that capture carbon dioxide in the atmosphere via photosynthesis. The roof could also provide habitats for endangered insects.

(c) The cafeteria's food service could utilize any food grown by the living green roof which would be a local source, reducing the school's carbon emissions from imported food transported by semi-trucks. The cafeteria's food service could also compost food waste and use the compost as soil for the roof.

(d) Using native plants for landscaping would drive out invasive species of plants. Native plants would also provide habitats for native species of animals.

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(e) Plant material, such as cork and bamboo, is biodegradable. When ~~that~~ carpet ~~[illegible]~~ made of plant material is replaced, it will biodegrade, whereas synthetic carpet made of plastics will take a long amount of time to break down.

PAGE FOR ANSWERING QUESTION 1

A) i) Carbon footprint is defined as the measure of the amount of carbon dioxide (CO_2) and other compounds released by various human activities

ii) The school's heating system is powered by the combustion of fossil fuels. Fossil fuels, which are used to create energy, create a large amount of carbon dioxide upon combustion. This is why students want to renovate the heating system; to reduce the carbon footprint of the school.

iii) The school could use renewable alternative energy sources to reduce its carbon footprint. This includes solar, wind, or hydroelectric energy. If the school were to use these as its main source of energy, much less CO_2 would be released.

b) Not having to obtain fossil fuels is a benefit. When we Frack to obtain oil and natural gas, or mine to obtain coal, we sometimes disturb the land by the destruction of various land habitats. Another environmental benefit of a living green roof is the severely reduced emmissions of greenhouse gases. These gases, including CO_2, CH_4, SO_2 and many others are released in large quantities when fossil fuels are burned to aquire electricity / thermal energy. Because of this heating system, the emmission of greenhouse gases could be reduced, which would reduce the rate of the

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greenhouse effect.

C) The school's cafeteria could purchase foods that were locally grown. This way, less gasoline would be needed to be burned to transport the food from other regions. This would greatly reduce greenhouse gas emmissions. Another practice the Cafeteria Service could use is buying foods from farms that did not use ~~extensive~~ many pesticides. This way it would motivate farmers in the school's area to grow crops without the use of pesticides. This is important as pesticides can be washed away by rain in agricultural runoff. If this happens, the pesticides will eventually make their way into larger bodies of water, and may be toxic to organisms in the aquatic ecosystem.

D) Using native plants would ~~increase~~ eliminate the chance of having an invasive species being introduced into this ecosystem. If an invasive species were to be introduced, the unfair competition between it and a native species would endanger the survival of the native species. This would also increase biodiversity as pollinating organisms could eventually live around the school to pollinate different plants at the school.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

E) Using flooring from natural materials is an environmental benefit as the flooring is from a renewable source. Bamboo or cork could easily be renewed by growing, meaning more flooring could be made. The carpet, however, is made from synthetic fibers. These fibers are made from petroleum, which is non-renewable. This means that the reduction in use of petroleum-based products may preserve our limited supply of petroleum.

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PAGE FOR ANSWERING QUESTION 1

(A, i) Carbon footprint: A measure of the amount of carbon dioxide and other carbon compounds released by various human activities.

(A, ii) ~~Sch~~ The ~~the~~ School's heating system is powered by fossil fuel combustion, which emits ~~carbon is the~~ Large quantities of carbon compounds results in an increase of the School's carbon footprint.

(A, iii) The School could switch from fossil fuel emissions to a more environmentally friendly form of energy, such as wind or hydroelectric power.

(B) The green roof will reduce CO_2 concentration in nearby air by plant photosynthesis. Also, the green roof will lead to ~~can in increase air quality~~ an increase of breathable oxygen in the nearby air by plant photosynthesis

(C) They could use more efficient cooking appliances to decrease energy usage. They can use ~~plastic tray food trays and recycle them otherwise~~ metal food trays that can be washed and reused, instead of plastic trays that cannot be used and will either become a part of the school's waste

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

(D) Native plants will not effect the current ecosystem while invasive plant species would. Also, Native plants are local to the nearby ecosystem which promotes environmental sustainability.

(E) using plant material over carpet (Synthetic fibers) would be environmentally beneficiable because the pollution emitted in creating the plant material is significantly less than that of carpet (Synthetic fibers).

PAGE FOR ANSWERING QUESTION 1

a.i.) A measure of the amount of carbon dioxide and other carbon compounds released by various human activities.

i.i.) The school is using fossil fuels as their source of heat, and this combustion can release different carbon compounds.

iii.) The school can stop using the fossil fuel combustion during after school hours and use it only if/when necessary.

b.) One environmental benefit is that green roofs have plants which can provide us with oxygen (trees) Another environmental benefit is that pollination can occur on this green roof.

c.) One practice could be to use trays that can continue to be used instead of discardable ones to decrease waste produced by the cafeteria. Another practice could be to educate the people who come to the cafeteria to only take what they know they'll eat so that their trash does not contribute to the waste.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

d.) One benefit of using native plants is that it'll be easier to maintain them since the school will know more about them. Another benefit of using native plants is that there will be more of there plants in the same area and it can increase the appeal of people to this landscaping since it will most likely fit in with the surrounding area.

e.) One environmental impact of this is that plants will have to be removed and killed [redacted] for human use and will not be able to provide the services in their ecosystem that they once did.

PAGE FOR ANSWERING QUESTION 1

A. Carbon footprint is a measure of the amount of carbon dioxide & other carbon compounds released by human activities. The heating system is using fossil fuel combustion, which releases huge amounts of carbon dioxide into the enviroment by burning the fossil fuel for energy. They could reduce the contribution of the heating system by installing better insulation reducing the need to use the heating unit.

B. It could conserve local water resources and reduce the need for consuming new resources.

C. They could grow and raise their own live stock and vegtables.

D. It would look beautiful and help give the native species names.

E. The use of plant material for flooring would last longer and the production of it would be more natural and easier on the enviroment

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PAGE FOR ANSWERING QUESTION 1

(a) i. A carbon footprint is a measure of the amount of carbon dioxide & other carbon compounds released by various human activities.

ii. The school's heating system is likely adding to the school's carbon footprint because it is provided by fossil fuel combustion.

iii. One realistic way to reduce the contribution of the heating system to the school's carbon footprint would be to incorporate specific features that conserve energy & utilize renewable energy sources.

(b) Two environmental benefits of a living green roof are that is sustainable & is environmentally friendly.

(c) Two practice's the cafeteria's food service could use to decrease the environmental impacts of Freemont High School are composting & creating their own garden.

(d) Two benefits of using native plants are that you are not introducing a new plant that could be dangerous to the plants around it & native plants grow better in their native environments.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

(e) one environmental benefit of using cork or bamboo as the new flooring instead of carpet is that when the floors need to be replaced again later on, then cork/bamboo is more biodegradable than carpet which is made of synthetic fibers.

1. (a)

'carbon footprint is a measure of the amount of carbon dioxide and other carbon compounds released by various human activity." the school's heating system doesn't conserve energy or utilize renewable energy sources. "" one way to reduce the contribution of the heating system to the school's carbon footprint would be a project incorporating a living green roof.

(b)

a living green roof would be a sustainable feature because it is eco-friendly. it would also conserve local water resources, and reduce the need for consuming new resources.

(c)

the source of heat being used in the cafeteria should conserve energy. it should also avoid the release of any chemical or thermal pollutants.

(d)

native plants belong there. plants that live in their natural habitats thrive, and have a positive impact on the environment.

(e)

having flooring made out of plant material

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

will be a good example for students to see how to be eco-friendly. Purchasing carpet with synthetic fibers will cost less, but giving companies who produce flooring like this, is supporting what they're doing. They will continue to stay in business as long as people still purchase their carpets.

AP® SAMPLE STUDENT RESPONSES AND SCORING NOTES
2018 AP ENVIRONMENTAL SCIENCE

Question 1

Sample Identifier: 1A
Score: 10

- 3 points were earned for part (a). 1 point was earned in (a)(i) for defining a carbon footprint as the "amount of carbon dioxide...released by various human activities." 1 point was earned in (a)(ii) for identifying that "the burning of Fossil [*sic*] fuels releases CO_2." 1 point was earned in (a)(iii) for describing that "to install better insulation...less heat is required to keep a room at a warmer temperature."
- 2 points were earned in part (b). 1 point was earned for identifying that a green roof "reduces the need for cooling and heating because of its insulative properties." 1 point was earned because the green roof will "increase biodiversity in the area."
- 2 points were earned in part (c). 1 point was earned for the cafeteria sourcing "its food from within 50 miles of its production to reduce the amount of CO_2 released by shipping." 1 point was earned to "utilize reusable plates and silverware to reduce the trash waste."
- 2 points were earned in part (d). 1 point was earned for discussing that native plants "will not need fertilizers...because it is designed to thrive in the existing environmental conditions." 1 point was earned for discussing that native plants "will not need increased irrigation because it is designed to thrive in the existing environmental conditions."
- 1 point was earned for part (e) for discussing that using flooring made of plant materials "is a renewable resource...the material is made of fast growing plants which are easier to regrow which makes it better than synthetic carpeting because the synthetics are made of petroleum products which are not renewable."

Sample Identifier: 1B
Score: 9

- 3 points were earned for part (a). 1 point was earned in (a)(i) for defining a carbon footprint as the "amount of carbon compounds produced by all human activity." 1 point was earned in (a)(ii) for identifying that "when fossil fuel is combusted...it will release carbon dioxide." 1 point was earned in (a)(iii) for describing that if "the school...keep[s] its thermostat to a lower temperature...there will be less combustion of fossil fuels [and]...less carbon dioxide released."
- 2 points were earned in part (b). 1 point was earned for identifying that "the plants on the roof produce oxygen." 1 point was earned because the "green roof may provide habitats for numerous animal species."
- 2 points were earned in part (c). 1 point was earned for describing "using locally grown produce to reduce the carbon dioxide produced during transportation of the vegetables." 1 point was earned by "serv[ing] more grains and vegetables than meat because less resources (such as land and water) are used to produce grains and vegetables than the same amount of livestock."
- 1 point was earned in part (d). 1 point was earned for describing that "native plants provide natural habitats or food for local species of insects and animals." No second point was earned because it is not true that native plants "enrich the soil with nutrients."
- 1 point was earned in part (e) for discussing that "plant material [for flooring] is biodegradable...Synthetic fibers, on the other hand, are persistent."

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Sample Identifier: 1C
Score: 8

- 3 points were earned for part (a). 1 point was earned in (a)(i) for defining carbon footprint as the "amount of carbon compounds...that are released by human activities." 1 point was earned in (a)(ii) because "fossil fuel combustion...releases carbon dioxide emissions." 1 point was earned in (a)(iii) for describing that "replacing the fossil fuel combustion system with a renewable energy source, such as wind...that then generate[s] electricity which can be used as a heating source."
- 2 points were earned in part (b). 1 point was earned for identifying that a living green roof "provides a habitat for organisms." 1 point was earned for identifying "more photosynthesizing plants" as an environmental benefit.
- 2 points were earned in part (c). 1 point was earned for describing that "serving food that belongs on a lower trophic level" will decrease the environmental impact, supported with the claim that "serving food on higher trophic levels–such as cattle...require more resources like water and crops in order to feed and sustain that cattle." 1 point was earned for describing how the cafeteria serving "organic food that did not use fertilizers or pesticides in its production process...would reduce the amount of persistant [*sic*] pesticides that accumulate in the environment."
- No points were earned in part (d).
- 1 point was earned in part (e). 1 point was earned for discussing that "to create synthetic fibers for carpeting, chemicals/toxins are used. These toxins...[are] released into the environment. Producing plant material flooring uses less of these chemicals, in the process."

Sample Identifier: 1D
Score: 7

- 3 points were earned in part (a). 1 point was earned in (a)(i) for defining a carbon footprint as "the amount of CO_2...released by different human activities." 1 point was earned in (a)(ii) for identifying that the "school's heating system burns fossil fuels which release carbon dioxide." 1 point was earned in (a)(iii) for describing that "the school can replace their heating system with solar panels, a renewable energy source that does not release any carbon emissions."
- 2 points were earned in part (b). 1 point was earned for identifying "more plants that capture carbon dioxide in the atmosphere via photosynthesis." 1 point was earned for identifying that "the roof could also provide habitats for endangered insects."
- 1 point was earned in part (c) for describing how the cafeteria "could utilize any food grown by the living green roof...reducing the school's carbon emissions from imported food transported by semi-trucks." No point was earned for "compost food waste" because there was no discussion of how the practice of composting food waste decreases the environmental impact of the school.
- No points were earned in part (d).
- 1 point was earned in part (e) for discussing that "plant material, such as cork and bamboo, is biodegradable. "When carpet made of plant material is replaced, it will biodegrade, whereas synthetic carpet...will take a long amount of time to break down."

Sample Identifier: 1E
Score: 6

- 3 points were earned in part (a). 1 point was earned in (a)(i) by defining "the amount of carbon dioxide... released by various human activities." 1 point was earned in (a)(ii) because the "combustion of fossil fuels...create[s]... carbon dioxide." 1 point was earned in (a)(iii) for describing that "the school could use renewable alternative energy sources...This includes solar, wind, or hydroelectric energy...as its main source of energy [and] much less CO_2 would be released."
- No points were earned in part (b).
- 2 points were earned in part (c). 1 point was earned for describing that if the "cafeteria could purchase foods that were locally grown...less gasoline would be needed to be burned to transport the food." 1 point was earned for describing the practice of "buying foods from farms that did not use many pesticides." This is a benefit because "the pesticides...may be toxic to organisms in the aquatic ecosystem."
- No points were earned in part (d).
- 1 point was earned in part (e) for discussing that "bamboo and cork could easily be renewed by growing, meaning more flooring could be made....carpet...fibers are made from petroleum which is non-renewable."

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Sample Identifier: 1F
Score: 5

- 2 points were earned in part (a). 1 point was earned in (a)(i) for defining "amount of carbon dioxide...released by various human activities." No point was earned in (a)(ii). The response did not specify carbon dioxide as the product of fossil fuel combustion. 1 point was earned in (a)(iii) for describing that the school "could switch from fossil fuel emissions to a more environmentally friendly form of energy, such as wind or hydroelectric power."
- 1 point was earned in part (b) for identifying that a living green roof can "reduce CO_2 concentration...by plant photosynthesis."
- 2 points were earned in part (c). 1 point was earned for describing "us[ing] more efficient cooking appliances to decrease energy use" by the cafeteria. 1 point was earned for describing "use metal food trays that can be washed and reused, instead of plastic trays that...will become a part of the school's waste."
- No points were earned in part (d).
- No point was earned in part (e).

Sample Identifier: 1G
Score: 4

- 1 point was earned in part (a). 1 point was earned in (a)(i) for the "amount of carbon dioxide...released by various human activities." No point was earned in (a)(ii). No point was earned in (a)(iii).
- 1 point was earned in part (b) because "plants...provide oxygen."
- 2 points were earned in part (c). 1 point was earned by describing "trays that can continue to be used instead of discardable [*sic*] ones to decrease waste produced by the cafeteria." 1 point was earned by "educat[ing] the people [students] to only take what they know they'll eat so that their trash does not contribute to the waste."
- No points were earned in part (d).
- No point was earned in part (e).

Sample Identifier: 1H
Score: 3

- 3 points were earned in part (a). 1 point was earned in (a)(i) for the "amount of carbon dioxide...released by human activities." 1 point was earned in (a)(ii) for identifying that "fossil fuel combustion...releases...carbon dioxide." 1 point was earned in (a)(iii) for describing that "installing better insulation [thus] reducing the need to use the heating unit."
- No points were earned in part (b).
- No points were earned in part (c).
- No points were earned in part (d).
- No point was earned in part (e).

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AP® SAMPLE STUDENT RESPONSES AND SCORING NOTES
2018 AP ENVIRONMENTAL SCIENCE

Sample Identifier: 1l
Score: 2

- 1 point was earned in part (a). 1 point was earned in (a)(i) for the "amount of carbon dioxide...released by various human activities." No point was earned in (a)(ii). No point was earned in (a)(iii).
- No points were earned in part (b).
- No points were earned in part (c). There was no discussion of how "composting" or "creating their own garden" could decrease the environmental impact in the cafeteria.
- No points were earned in part (d).
- 1 point was earned in part (e) for discussing "when the floors need to be replaced again later on, then cork/bamboo is more biodegradable than carpet."

Sample Identifier: 1J
Score: 1

- 1 point was earned in part (a). 1 point was earned in (a)(i) for the "amount of carbon dioxide...released by various human activity." No points were earned in (a)(ii). No points were earned in (a)(iii).
- No points were earned in part (b).
- No points were earned in part (c).
- No points were earned in part (d).
- No point was earned in part (e).

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2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

   (a) **Describe** one environmental benefit associated with an offshore wind project.

   (b) **Identify** and **describe** one potential economic effect of an offshore wind project.

   (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

   The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

   (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

   (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

   (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

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AP® ENVIRONMENTAL SCIENCE
2018 SCORING GUIDELINES — Version 1.0

Question 2

An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

(a) **Describe** one environmental benefit associated with an offshore wind project.

(1 point for correct description of environmental benefit associated with offshore wind project)

- Reduced environmental damage from decreased reliance on fossil fuels, such as:
  - Less habitat/ecosystem destruction due to less exploration and extraction (less mining or drilling, etc.)
  - Less air/soil/water pollution (less exhaust emissions, pipeline leaks, tanker leaks) due to less transportation of fossil fuels
  - Less air pollution (no/fewer particulates, VOCs, NOx, SOx, CO2, or greenhouse gases) due to less fossil fuel combustion
- Reduced environmental damage from decreased reliance on nuclear power, such as:
  - No risk of radioactive releases with accidents
  - No hazardous/radioactive wastes to store
  - Less exploration/ extraction/processing for uranium ore
- Increased aquatic habitat/artificial reefs for barnacles, sponges, other invertebrates, fish

(b) **Identify** and **describe** one potential economic effect of an offshore wind project.

(2 points; 1 point for correct identification of potential economic effect and one point for correct description of identified economic effect. The description point cannot be earned without correctly identifying a potential economic effect.)

Identify one potential economic effect	Describe one potential economic effect
Job creation (+)	• Jobs will be created in construction, operation, maintenance, etc. in wind project
Additional income (+)	• Local municipalities receive more taxes (income, sales, property) paid by utility and workers • Wind power company will make money/profits in the long run
Decreased electricity costs (+)	• Electrical production costs will be lower, which will reduce electricity rates for consumers
Less reliance on foreign energy resources (+)	• Transportation costs to deliver fuels will be reduced
High initial construction/ high maintenance costs (-)	• Local taxes/fees/rates will increase to support construction costs associated with building of facility • Parts and personnel must be transported off-shore for construction, repairs and maintenance
Decreased property value (-)	• Property values will decrease in coastal areas due to unfavorable aesthetics
Loss of income (-)	• Turbines negatively affect the aesthetics, which negatively impacts tourism, fishing, whale watching etc. • Local fishing opportunities will be disrupted • Less revenue for fossil fuel companies as demand decreases
Job loss (-)	• Jobs will be lost in the traditional energy production sectors (coal, nuclear)
Subsidies cost (-)	• State subsidies to offset cost of building offshore and transmission lines to coast will increase; costs may be recovered with increased taxes

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(c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

(1 point for correct description of energy source from ocean)

- Use of tidal movement/currents to turn turbines
- Utilize a device designed to capture energy from wave motion
- Harness the solar energy absorbed by the oceans/use natural thermal gradient in tropical and temperate oceans to create electricity (OTEC – Ocean Thermal Energy Conversion)
- Harvest algae and convert to biofuel

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs $1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

(d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$(0.80) \times (2.0 \times 10^6 MWh) = 1.6 \times 10^6 MWh$$

(e) Customers in the service area pay $0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 MWh \times \frac{\$(2 \times 10^{-1})}{kWh} \times \frac{1 \times 10^3 kWh}{1 MWh} = \$3.2 \times 10^8 = \$320,000,000 = \$320 \text{ million}$$

(f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 MWh \times \frac{1 \text{ turbine}}{4MW} \times \frac{1}{2 \times 10^2 \text{ turbines}} = 2 \times 10^3 \text{hr} = 2{,}000 \text{ hours}$$

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a) An offshore wind project can reduce the need for electricity from other, more detrimental energy sources, particularly from fossil fuels. Reducing the reliance on fossil fuels lessens greenhouse gas emissions and helps to combat global climate change.

b) An offshore wind project can stimulate the economy by providing new construction and "green" jobs. ← the construction of the wind project will bring new jobs as well as the maintenance that will be required for years to come

c) The ocean can provide renewable energy for electricity through the use of tidal turbines. As the tides come in and out, they rotate a turbine that produces electricity.

d) 2.0×10^6 MWh * (.80) = 1.6×10^6 MWh = 80% of annual electric demand

If the wind project produces 1.6×10^6 MWh of electricity,

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$800 | 1,600 (2000)

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

then it will provide 80% of the annual electrical demand for the service area.

e)

$1.6 \times 10^6 \text{ MWh} * \left(\frac{1000 \text{ kWh}}{1 \text{ MWh}}\right) = 1.6 \times 10^9 \text{ kWh}$ of electricity

$1.6 \times 10^9 \text{ kWh} * \left(\frac{\$0.20}{1 \text{ kWh}}\right) = 3.2 \times 10^8 \$ = \$320{,}000{,}000$

The revenue will be $\$3.2 \times 10^8$ or \$320 million

f)

200 turbines $\times \left(\frac{4 \text{ MW}}{\text{turbine}}\right)$ 800 MW = capacity of all turbines

80% of annual electrical demand $= 1.6 \times 10^6$ MWh

$(1.6 \times 10^6 \text{ MWh}) \times \left(\frac{1}{800 \text{ MW}}\right) = 2 \times 10^3 \text{ h} = 2000$ hours

In order to provide 80% of the annual electrical demand in the service area, the turbines have to operate for 2,000 hours

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(a) It produces clean energy for cities on the mainland.

(b) It will create jobs for engineers that will be required to maintain the windfarm.

(c) Underwater turbines can be placed along the coast that are turned by tidal energy when the water moves in land or out to sea

(d) 2.0×10^6 MWh/year $\cdot$ 0.8 = $\boxed{1.6 \times 10^6 \text{ MWh/year}}$

(e) $\frac{\$0.20}{\text{kWh}} \times \frac{1000 \text{ kWh}}{1 \text{ MWh}} \times \frac{1.6 \times 10^6 \text{ MWh}}{1 \text{ year}} = \$3.2 \times 10^8/\text{year}$

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(f) $\frac{4\ MW}{1\ turbine} \times 200\ turbines = 800\ MW$

$\frac{1.6 \times 10^6\ MWh/year}{800\ MW} = 2{,}000\ hr/year$

1,000,000 watts = 1 MW
1000 watts = 1 KW

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

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(f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

a) Offshore wind projects provide a source of renewable, non-damaging source of energy and is growing in popularity as fossil fuels become scarce. Since wind power is readily available and cannot be depleted, there is no risk of running out; it is thus renewable and emits much less, if any greenhouse gases. Its only emissions of GHGs may come from its construction.

b) An economic benefit of offshore wind projects would be the creation of jobs. People are necessary to construct and design such large turbines, which opens up a position to be filled and money to be made by the individual.

c) Tidal power is an additional way that oceans can provide renewable energy. These method of energy generation harnesses the strong movements of ocean currents and tides to spin a turbine to generate electricity.

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C

d) $.80 \times (2.0 \times 10^6) = \boxed{1.6 \times 10^6 \text{ MWh}}$

2.0
×.80
000
+1600
1600

The wind project needs to produce 1.6×10^6 MWh of electricity to service 80% of the region's needs.

e) $\frac{\$0.20}{\text{KWH}} \cdot \frac{1000 \text{ KWH}}{1 \text{ MW}} \cdot 1.6 \times 10^6 \text{ MWh}$

200×1000

$200 \times 1.6 \times 10^6$

$2 \times 10^2 (1.6 \times 10^6)$

3.2×10^8

$\boxed{\$320000000}$

1.6
×2
32

The amount of revenue collected would be $320,000,000.

f) $\frac{1.6 \times 10^6 \text{ MWh}}{200 \text{ turbines (4 MW)}} = \frac{1.6 \times 10^6 \text{ MWh}}{800 \text{ MW}} = \frac{1.6 \times 10^6}{8 \times 10^2} =$

8×10^2

0.2
8 | 1.6 0
-16
00

0.200×10^4

$\boxed{2000 \text{ hours}}$

These turbines must operate for 2000 hours to produce enough energy to satisfy 80% of the needs.

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2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

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A) One environmental benefit of an offshore wind project is that the electricity it produces will decrease the area's dependency on fossil fuel combustion, and therefore reduce the emissions of greenhouse gases such as carbon dioxide.

B) One potential economic effect of an offshore wind project is that it will need a large amount of funding to be built, which may require a tax increase.

C) Another way, besides wind power, that the ocean provide a source of renewable energy for the generation of electricity is through tidal power. As the ocean water moves back and forth with the

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tides, it will spin an underwater turbine to generate electricity.

D) $0.80 \times 2.0 \times 10^6 = 1.6 \times 10^6$ MWh of electricity

E) 1.6×10^6 MWh $\times \frac{1{,}000 \text{ kwh}}{1 \text{ MWh}} = 1.6 \times 10^9$ kwh

1.6×10^9 kwh $\times \$0.20/\text{kwh} = .32 \times 10^9$ dollars

$= \$320{,}000{,}000$

1
1.6
×0.2
3 2
+0 0 0
.32

F)

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A. Less fossil fuels need to be used for energy leading to the release of fewer green house gasses (CO_2).
B. The initial cost will be expensive to build but the project will lead to cheaper energy once it is functional. Consumers will have to pay less for energy as the wind is not a cost power companies must obtain like coal or oil.
C. Tidal energy can produce renewable energy. The movement of the tides moves turbines and generates electricity and energy.

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D. 2,000,000
× .8
1,600,000 1.6×10^6 MWh

E. 1,600,000
.2
320,000

200 × 4 = 800 MW

$1.6 \times 10^6 \times 1 \times 10^3 = 1.6 \times 10^9$
$1.6 \times 10^9 \times .2$
3.2×10^8 $\$ 3.2 \times 10^8$

F. 4 × 200 = 800MW
$800 \overline{)1.6 \times 10^6}$

800 × 2 = 1,600
1600 × 1000 = 1.6×10^6
2 × 1000 = 2000

2000 hours

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1,600,000,000 × .2 = 320,000,000.0

1,600,000 / 800

2000000 × .8 = 1600000.0

a) winds are stronger over the ocean, so an offshore wind project would be beneficial because the net energy would be very high, allowing wind to replace more of the reliance on fossil fuels.

b) The increased net energy is also an economic benefit because an off shore wind farm could produce more energy while building less turbines.

c) Tidal energy is renewable; it uses the kinetic energy of naturally occuring ocean tides to produce electricity.

d) 2,000,000 MWh × 0.8 = 1,600,000 MWh

e) $1{,}600{,}000 \text{ MWh} \times \frac{1000 \text{ kWh}}{1 \text{ MWh}} \times \frac{\$0.2}{1 \text{ kWh}} = \$320{,}000{,}000$

f) $\frac{1{,}600{,}000 \text{ MWh}}{200 \text{ turbines} \times 4 \text{ MW}} = 200{,}000 \text{ hours}$

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a.) One environmental benefit of an offshore wind project is that it could potentially be a sustainable source of energy. When the wind turbines spin, they produce electricity that can be used to power homes and buildings.

b.) One potential economic effect of an offshore wind project is the creation of jobs. Since there is a lot of work involved in building, installing, and maintaining wind turbines, many new jobs could be created.

c.) Another way oceans can provide electricity is through hydroelectric power. Hydroelectric power uses the kinetic energy of flowing

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and falling water to produce electricity.

d.) $2.0 \times 10^6 = 20,000,000$ MWh (total electrical demand)

$\times \quad 0.8$

$16,000,000$ MWh

1.6×10^6 MWh of electricity

e.) $16,000,000$

$\times \quad 0.2$

$32,000,000 = \$3,200,000$

f.) $200 \overline{)16,000,000}$ $\quad 00080,000$ MW $\quad \frac{80,000}{4} = 20,000$

$-16\,00\downarrow$

0

20,000 hours

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a.) one environmental benefit of an offshore wind project is that no pollution is produced. Harnessing wind for energy is a clean alternative to fossil fuels. No pollution is produced, unlike the harmful gases that are produced during the burning of fossil fuels.

b.) one potential economic effect of an offshore wind project would be an increase of jobs. The building of the wind turbines would require lots of labor, meaning an increase in the need of workers.

c.) Another way other than wind power that oceans can provide renewable energy is through tides. Tidal energy can be produced by generators that capture out going tides, causing a turbine to spin and generating power.

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This process also results in the production of no pollution

d.) $\begin{array}{r} 200 \\ \times\ 4 \\ \hline 800\ \text{MW} \end{array}$ $2.0 \times 10^6 = 2,000,000$ Mwh per year

$2,000,000 \times 0.2 = 1,800,000$ 80% of annual

The wind project needs to produce 1.8 million Mwh in order to provide 80% of the annual electrical demand.

e.) 0.20 per kWh 1,000 kilo in 1 mega

$1,800,000,000 \times 0.20 = 1,400,000,000$ $1,800,000 \times 1,000$

The wind turbines would produce $1,400,000,000 by providing 80% of the annual electrical demands.

f.) 1,800,000 → 80% of annual

wind turbine → 24 hours

$24 \times 7 = 168$ $24 \times 5 = 120$

$1,800,000 \div 24 =$

$24\overline{)1,800,000}$ 750

168

120

120

0

750 hours

In order to produce 80% of the annual electrical demand, the wind turbines need to operate for a total of 750 hours.

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   (a) **Describe** one environmental benefit associated with an offshore wind project.

   (b) **Identify** and **describe** one potential economic effect of an offshore wind project.

   (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

   The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

   (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

   (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

   (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

a) One environmental benefit is the usage of a natural renewable resource to generate electricity.

b) Turbines are expensive to make and to keep well maintained.

c) Oceans can provide renewable energy through hydroelectric power. A generator powered by the water from the oceans allows electricity to be made naturally.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

d) Electrical demand = $2.0 \times 10^6 \times (.8)$

2.0×10^6

$\times \quad 8.0 \times 10^{-1}$

16.0×10^5

16×10^5 mWh

e) $.20 \times .8$

$.20$

$\times .80$

00

$+ 160$

$.0160$

f)

GO ON TO THE NEXT PAGE.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

(a) **Describe** one environmental benefit associated with an offshore wind project.

(b) **Identify** and **describe** one potential economic effect of an offshore wind project.

(c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs $1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

(d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

(e) Customers in the service area pay $0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

(f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

A) A benefit of an offshore wind project is that wind turbines do not produce and release any greenhouse gases.

B) An economic effect of this project is that the energy is renewable, which means that it will always be available.

C) Other than wind power, oceans can provide renewable energy through hydroelectric power, which uses the water to spin a turbine to produce energy

D) The wind project needs to produce 1.6×10^6 MWh per year in order to provide 80% of the annual electrical demand

E) The revenue that will be produced is $82,000

F) In order for the wind turbines to produce 80% of the energy it would need to run for at least 12 hours.

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AP® SAMPLE STUDENT RESPONSES AND SCORING NOTES
2018 AP ENVIRONMENTAL SCIENCE

Question 2

Sample Identifier: 2A
Score: 10

- 1 point was earned in part (a) for describing that "Reducing reliance on fossil fuels lessens greenhouse gas emissions."
- 2 points were earned in part (b). 1 point was earned for identifying "new...'green' jobs" as an economic benefit and 1 point was earned for describing that there will be new jobs in "the construction of the wind project...as well as the maintenance that will be required".
- 1 point was earned in part (c) for correctly describing "the use of tidal turbines [which]...rotate a turbine that produces electricity."
- 2 points were earned in part (d). 1 point for the correct setup with units and 1 point for the correct answer.
- 2 points were earned in part (e). 1 point for the correct setup with units and 1 point for the correct answer.
- 2 points were earned in part (f). 1 point for the correct setup with units and 1 point for the correct answer.

Sample Identifier: 2B
Score: 9

- No points were earned in part (a).
- 2 points were earned in part (b). 1 point was earned for identifying "create jobs" as an economic benefit, and 1 point was earned for describing that "engineers...will be required to maintain the wind farm."
- 1 point was earned in part (c) for describing that "Underwater turbines...are turned by tidal energy."
- 2 points were earned in part (d). 1 point for the correct setup with units and 1 point for the correct answer.
- 2 points were earned in part (e). 1 point for the correct setup with units and 1 point for the correct answer.
- 2 points were earned in part (f). 1 point for the correct setup with units and 1 point for the correct answer.

Sample Identifier: 2C
Score: 8

- No points were earned in part (a) because a direct relationship between an increase in wind energy and a decrease reliance on fossil fuels is not described.
- 2 points were earned in part (b). 1 point was earned for identifying "the creation of jobs", and 1 point was earned for describing "People are necessary to construct and design such large turbines."
- 1 point was earned in part (c) for describing that "the strong movements of ocean currents...to spin a turbine...generate electricity."
- 1 point was earned in part (d). No points were earned for the setup because units were missing. 1 point was earned for the correct answer.
- 2 points were earned in part (e). 1 point for the correct setup with units and 1 point for the correct answer.
- 2 points were earned in part (f). 1 point for the correct setup with units and 1 point for the correct answer.

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AP® SAMPLE STUDENT RESPONSES AND SCORING NOTES
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Sample Identifier: 2D
Score: 7

- 1 point was earned in part (a) for describing that the wind farm "will decrease the area's dependency on fossil fuel combustion, and therefore reduce the emissions of greenhouse gases."
- 2 points were earned in part (b). 1 point was earned for identifying that the project "will need a large amount of funding to be built" and 1 point for describing that the funding "may require a tax increase."
- 1 point was earned in part (c) for describing "As the ocean water moves back and forth with the tides, it will spin an underwater turbine to generate electricity."
- 1 point was earned in part (d). No points were earned for the setup because units were missing. 1 point was earned for the correct answer.
- 2 point was earned in part (e). 1 point for the correct setup with units and 1 point for the correct answer.
- No points were earned in part (f).

Sample Identifier: 2E
Score: 6

- 1 point was earned in part (a) for describing that "less fossil fuels need to be used for energy leading to the release of fewer greenhouse gases (CO_2)."
- 1 point was earned in part (b) for identifying "the initial cost will be expensive to build." The description point was not earned.
- 1 point was earned in part (c) for describing "The movement of the tides moves turbines and generates electricity."
- 1 point was earned in part (d). No points were earned for the setup because units were missing. 1 point was earned for the correct answer.
- 1 point was earned in part (e). No points were earned for the setup because units were missing. 1 point was earned for the correct answer.
- 1 point was earned in part (f). No points were earned for the setup because units were missing. 1 point was earned for the correct answer.

Sample Identifier: 2F
Score: 5

- No points were earned in part (a).
- No points were earned in part (b).
- No points were earned in part (c). There is no mechanism described for harnessing tidal energy.
- 2 points were earned in part (d). 1 point for the correct setup with units, and 1 point for the correct answer.
- 2 points were earned in part (e). 1 point for the correct setup with units, and 1 point for the correct answer.
- 1 point was earned in part (f) for the correct setup with units.

Sample Identifier: 2G
Score: 4

- No points were earned in part (a).
- 2 points were earned in part (b). 1 point was earned for identifying "the creation of jobs" as an economic benefit and 1 point was earned for describing that those jobs are needed for "building, installing, and maintaining wind turbines".
- No points were earned in (c).
- 2 points were earned in part (d). 1 point for the correct setup with units, and 1 point for the correct answer.
- No points were earned in part (e).
- No points were earned in part (f).

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Sample Identifier: 2H
Score: 3

- No points were earned in part (a).
- 2 points were warned in part (b). 1 point was earned for identifying "an increase in jobs" as an economic factor and 1 point was earned for describing that "building of wind turbines would require lots of labor, meaning an increase in the need of workers."
- No points were earned in part (c).
- 2 points were earned in part (d). 1 point for the correct set-up with units and 1 point for the correct answer.
- 1 point was earned in part (e) for the correct setup with units.
- No points were earned in part (f).

Sample Identifier: 2I
Score: 2

- No points were earned in part (a).
- 1 point was earned in part (b) for identifying that "turbines are expensive to make." as an effect. No points were earned for the description.
- No points were earned in part (c).
- 1 point was earned in part (d) for the correct answer.
- No points were earned in part (e).
- No points were earned in part (f).

Sample Identifier: 2J
Score: 1

- No points were earned in part (a) because a decreased reliance on fossil fuels was not described.
- No points were earned in part (b).
- No points were earned in part (c).
- 1 point was earned in part (d) for the correct answer.
- No points were earned in part (e).
- No points were earned in part (f).

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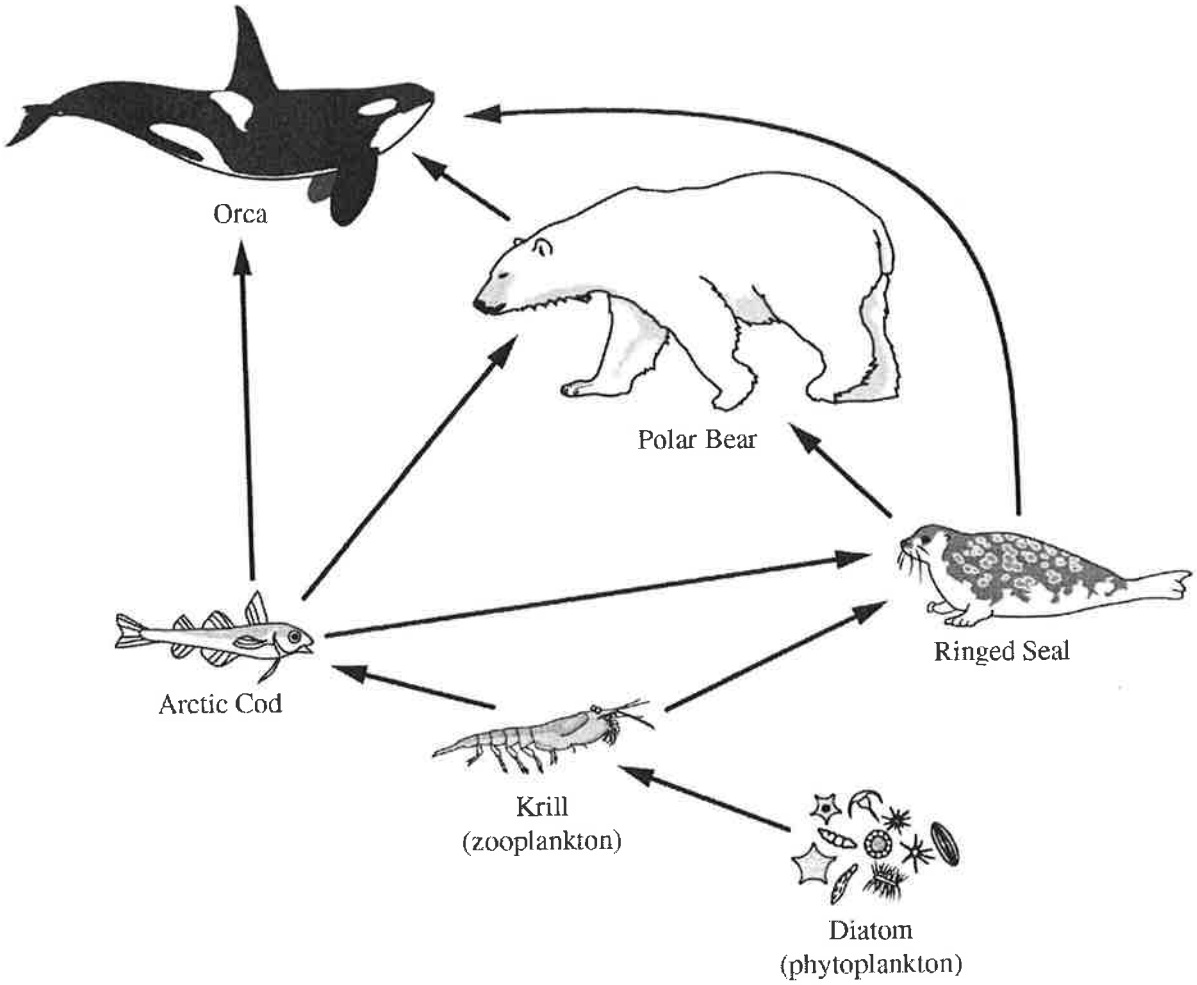
3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	
(ii) **Identify** a primary consumer	
(iii) **Identify** a secondary consumer	

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

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As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

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Question 3

An Arctic food web includes the following organisms.

(a) Refer to the diagram above to complete the following table.

(3 points; 1 point for correct identification of each organism in the table)

	Organism from Arctic food web
(i) **Identify** a primary producer	Diatom (phytoplankton)
(ii) **Identify** a primary consumer	Krill (zooplankton)
(iii) **Identify** a secondary consumer	Cod or seal

(b) Other than showing which organisms are consumed by others, **describe** what is indicated by the direction of the arrows in the diagram.

(1 point for correct description of what is indicated by the direction of the arrows)

- Shows the flow of energy among trophic levels
- Shows the flow of matter through trophic levels

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(1 point for correct description of how the change in sea ice habitat affects ability to hunt and feed)

- Decreasing area of hunting ground (area of ice used for hauling out/ fewer seal breathing holes/seals are a less available food source due to more open water) makes it more difficult for polar bears to get food
- Increasing area/distance between hunting ground means the polar bears have to exert more energy to swim to find food/physical exhaustion from swimming results in less energy available for hunting
- Increasing physiological stress (dehydration, exhaustion, cub mortality, etc.) because polar bears are not physiologically adapted to warmer temperatures)
- Increasing the time between successful kills results in bears spending more time waiting/hunting for prey

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

(2 points; 1 point for correct explanation of the connection between melting ice and the increased absorption of sun's energy and 1 point for correct explanation that increased absorption of sun's energy leads to increased melting of ice (completing the positive feedback loop)

- Melting of sea ice leads to a decrease in albedo or reflectivity leads to water surfaces absorbing more of the sun's energy

AND

- Increasing absorption of sun's energy warms the water surface further, which leads to further ice melt (completes positive feedback loop)

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(1 point for a correct reason why a species may migrate a long distance)

- Limited food/water supply leads to migration to locations with more food/water supply
- Food supply migrates and species follows prey
- More hospitable climate during certain seasons
- Availability of mates/breeding/birthing occurs in different location
- Protection of offspring from predators

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(1 point for correct description of one commercial activity, other than whaling)

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(1 point for correct strategy linked to activity in (ii))

Description of commercial activity	Description of one strategy
• Fishing nets entangle whales as by-catch • Fishing gear can accidently trap	• Require change of fishing method (location, timing, or materials) that traps whales to reduce the number of whales trapped in nets/gear • Fines for discarded fishing gear (long-line gear, ropes for hauling pots up, etc.) so less gear is discarded reducing the number of whales trapped in gear
• Ships and whales use the same channels, which can increase number of ship strikes	• Improved navigational technology to spot whales that are close to ships in order to avoid collisions • Increased education of ship captains and crews about whale habitat/migration routes/feeding behaviors in order to reduce ship collisions with whales • Expansion of low-speed navigational zones around ports to reduce ship collisions with whales
• Noise pollution from seismic surveys/sonar/engine noise can disrupt a whale's internal navigational system	• Reduction of seismic survey activity/sonar use in coastal areas to reduce exposure to noise pollution • Installation of quieter motors to reduce or eliminate noise pollution

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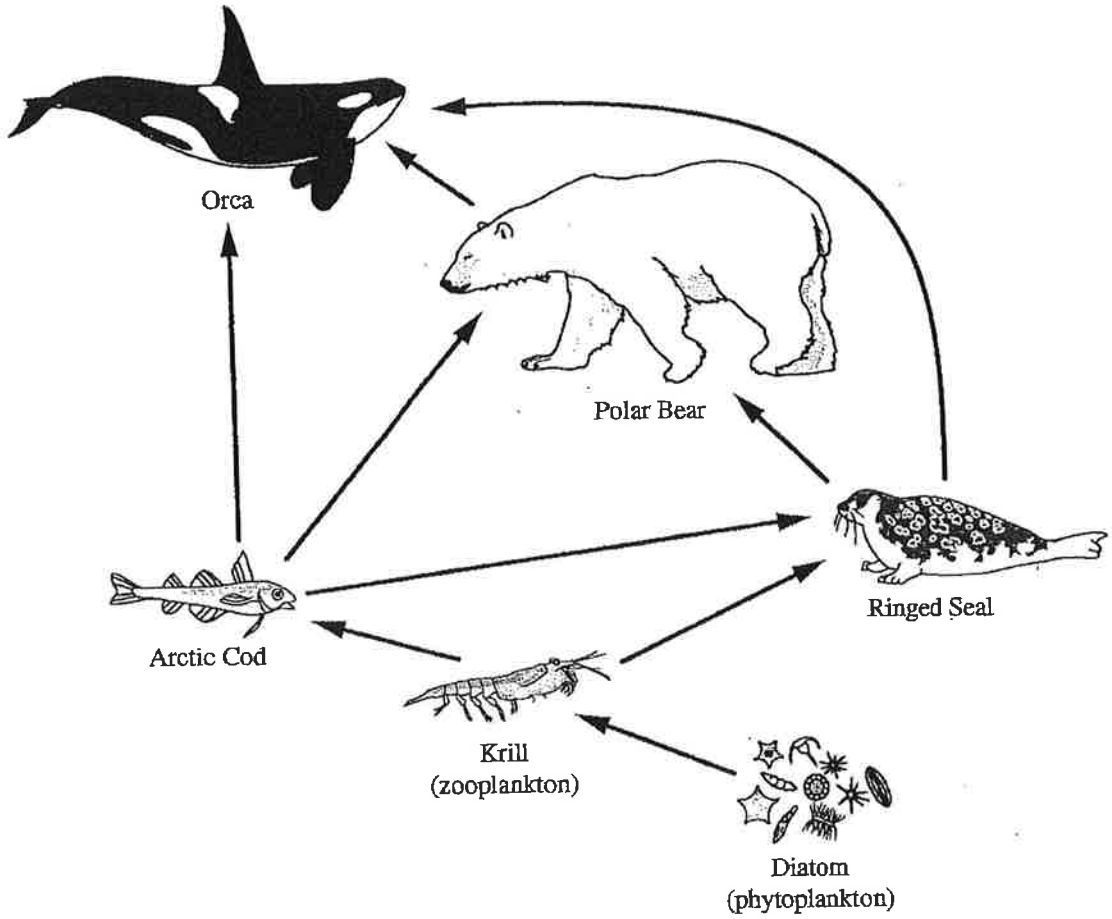
3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	Diatom
(ii) **Identify** a primary consumer	Krill
(iii) **Identify** a secondary consumer	Arctic Cod

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(a) (i) Diatom

(ii) Krill

(iii) Arctic Cod

(b) The ~~[illegible]~~ arrows in the diagram represent the flow of energy in an ecosystem

(c) Due to decreasing sea ice, the polar bears are losing contact with one of their primary prey. Since ringed seals have to breathe from the surface, they go to holes in the ice to breathe. With shrinking ice, the seals can breach the surface virtually anywhere which means the polar bears on the ice cannot attack them. The polar bears also have a much smaller area to hunt in which means less seals are around them to catch.

(d) Melting sea ice means less ice is reflecting the Sun's rays which leads to the warming of the water which goes back to melting more sea ice to form a positive feedback loop.

(e) (i) One reason a species may migrate a long distance is to go where food is more plentiful in order to raise offspring.

(ii) One commercial activity other than whaling that could kill right whales is shipping. Cargo ships carry a substantial amount of goods and if a whale breaches the surface in front of a ship, there is not anything

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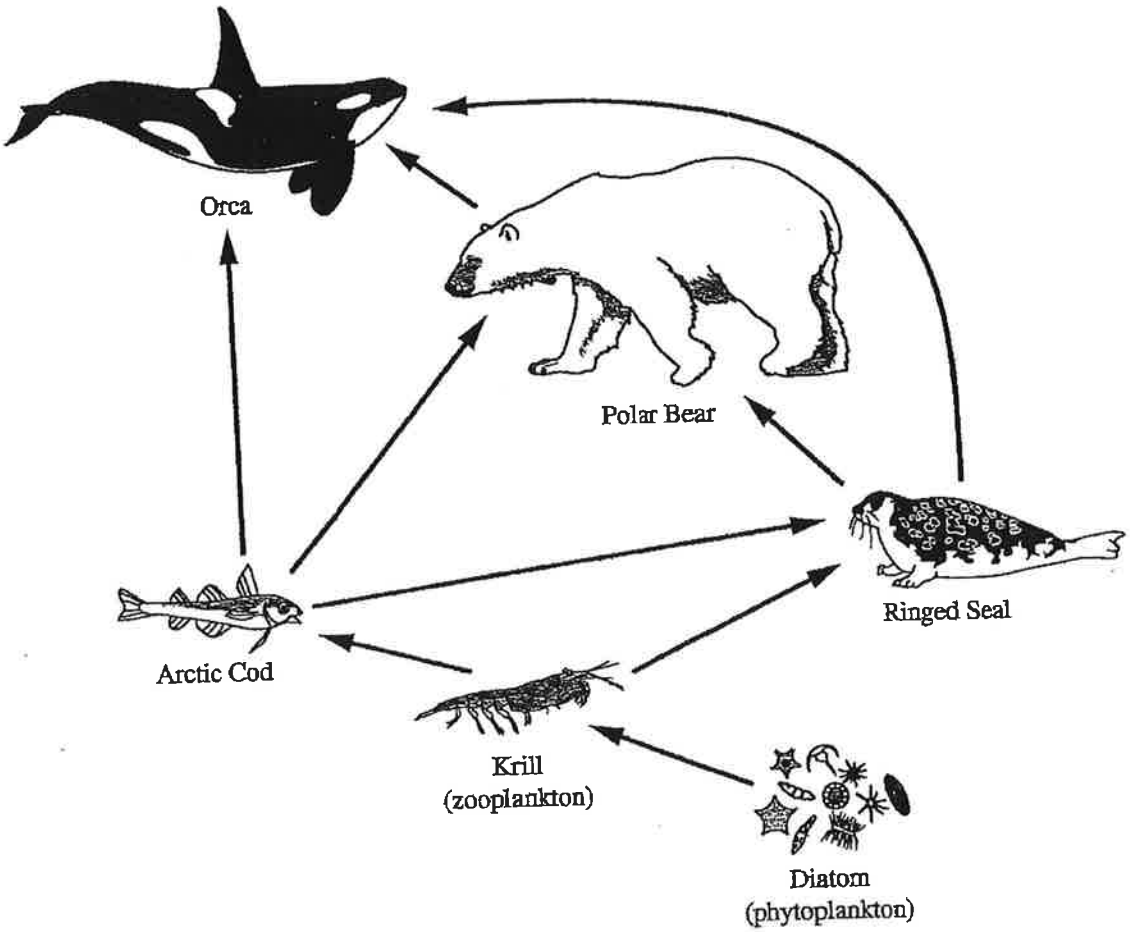
ADDITIONAL PAGE FOR ANSWERING QUESTION 3

to do to stop the ship from hitting it.

(iii) A way to decrease the amount of deaths caused by this activity is to require those in operation of large commercial ships to have an awareness of right whale migratory patterns to have an idea of when and where to look out for whales. This would prevent deaths because during migration season, boats could avoid certain areas of be more careful while travelling through them.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	DIATOM
(ii) **Identify** a primary consumer	KRILL
(iii) **Identify** a secondary consumer	RINGED SEAL

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

a.i) Primary producer: Diatom

a.ii) primary consumer: Krill

a.iii) secondary consumer: Ringed Seal.

b.) The flow of energy is indicated by the arrows.

c.) Due to global warming, there has been a dramatic change in Sea ice habitats, and in turn affect Polar bears' ability to hunt and feed. This is because global temperature increases allow sea ice to melt, and the polar bears no longer have the proper platform and footing to hunt for seals and fish.

d.) The melting sea ice contributes to a positive feed back loop that increases Arctic warming. Naturally, sea ice reflects light and heat emitted from the sun. However, Oceans on the other hand absorb heat better than ice. When the sea ice melts, less surface area is exposed to reflect heat, and in turn the ocean absorbs the heat

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instead, ~~and~~ increasing both ocean and atmospheric temperatures. The increase in temperature melts more ice, and the vicious cycle continues.

ei). One reason that a species migrates along distance is to reconvene with a partner to mate.

eii) One commercial activity that leads to the death of right whales is noise pollution from cargo ships. These giant ships have powerful engines that emitt very loud sounds. whales use sonar to find its way under water, and the noise generated from these ships disorients the whales, and impairs their ability to navigate. If the whale fails to find its food source due to the noise, it will die.

eiii) Marine and nautical engineers can design ships with quieter engines. ~~This is done either by~~ A common method to reduce engine noise is to create vibration proof hulls, which is done by suspending the engine and creating softer pores of impact to absorb the vibration.

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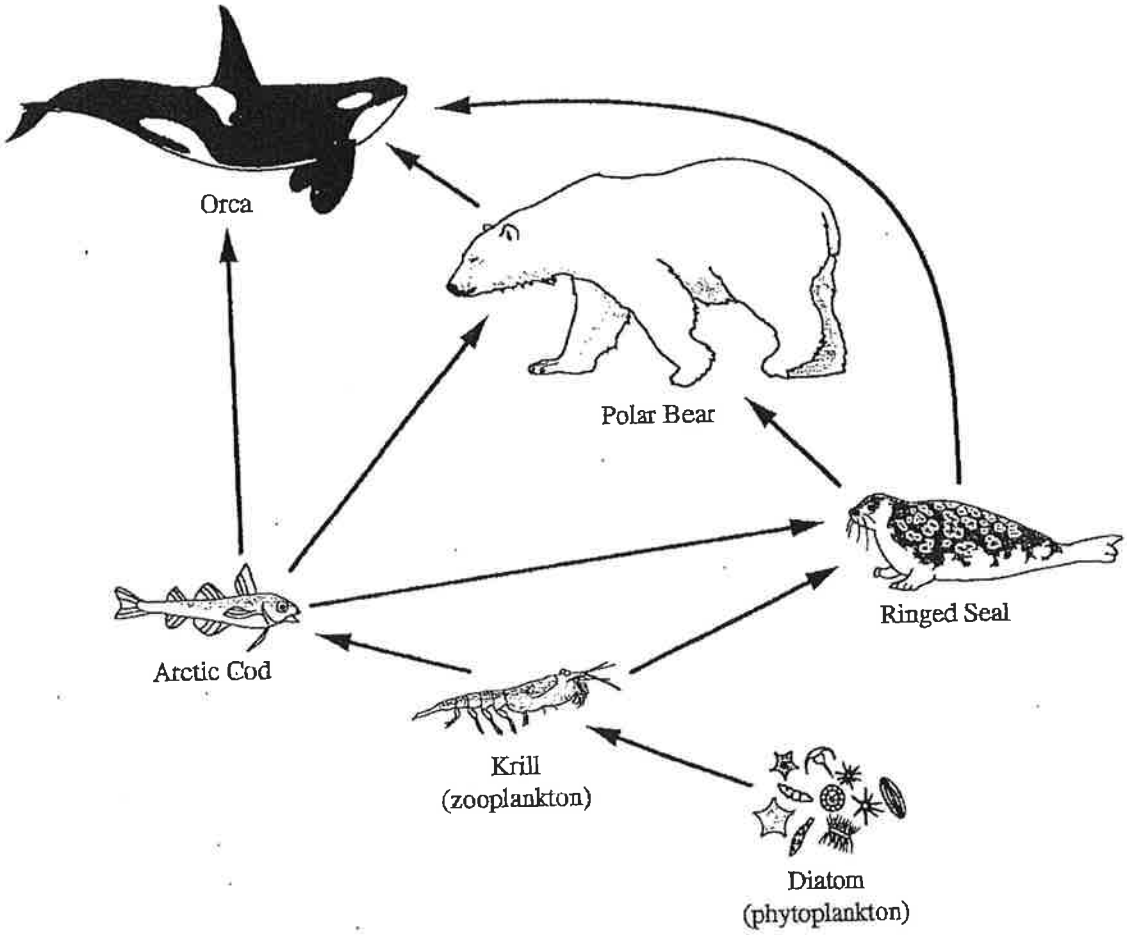
3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	~~phytoplankton~~ Diatom
(ii) **Identify** a primary consumer	Krill
(iii) **Identify** a secondary consumer	Arctic cod

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

3. a) i) (phytoplankton) Diatom is a primary producer

3 a) ii) Krill is a primary consumer

3. a) iii) Arctic cod is a secondary consumer

3. b) The movement of energy through the ecosystem is also shown by the arrows.

3. c) The polar bears used to know the precise location of where the ringed seals would be, as they would only come to the holes in the ice to breathe. But since all the ice has been significantly reduced, the seals can come up to breathe anywhere, making it hard for polar bears to identify the location of the seals, and making it harder for them to get food.

3. d). Water vapor is a greenhouse gas, meaning it traps outgoing infrared radiation and causes the temperature of the earth to rise. In a positive feedback loop, the temperature of the earth increases, causing ice to melt and water vapor to increase in the atmosphere, and causing the temperature of

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

the Arctic in this instance to increase even more, and the cycle continues.

3.e.i) Animals may migrate as a result of the changing of the seasons. For example, if a bird prefers warmer climates, it may fly south during the winter as it is warmer there during the winter, and may fly back north during the summer, as it isn't too hot in the north during the summer. This example is based on a bird in the Northern Hemisphere.

3eii) Large boats that are used for cruises or fishing often have sonar detectors on the bottom of the boat to measure the depth of the water. This can interfere with the whales own sonar system, causing the baby whales to seperate from their mothers due to their disorientation and be eaten by predators, or it can cause the whales to be disorientate so much that they never make it to their destination.

3.e.iii) A way to reduce the sonar activity that interferes with the whales sonar systems is to create laws that prevent the use of sonar activity during certain times of the year, such as when the whales are migrating, in the areas where whales are likely to be found.

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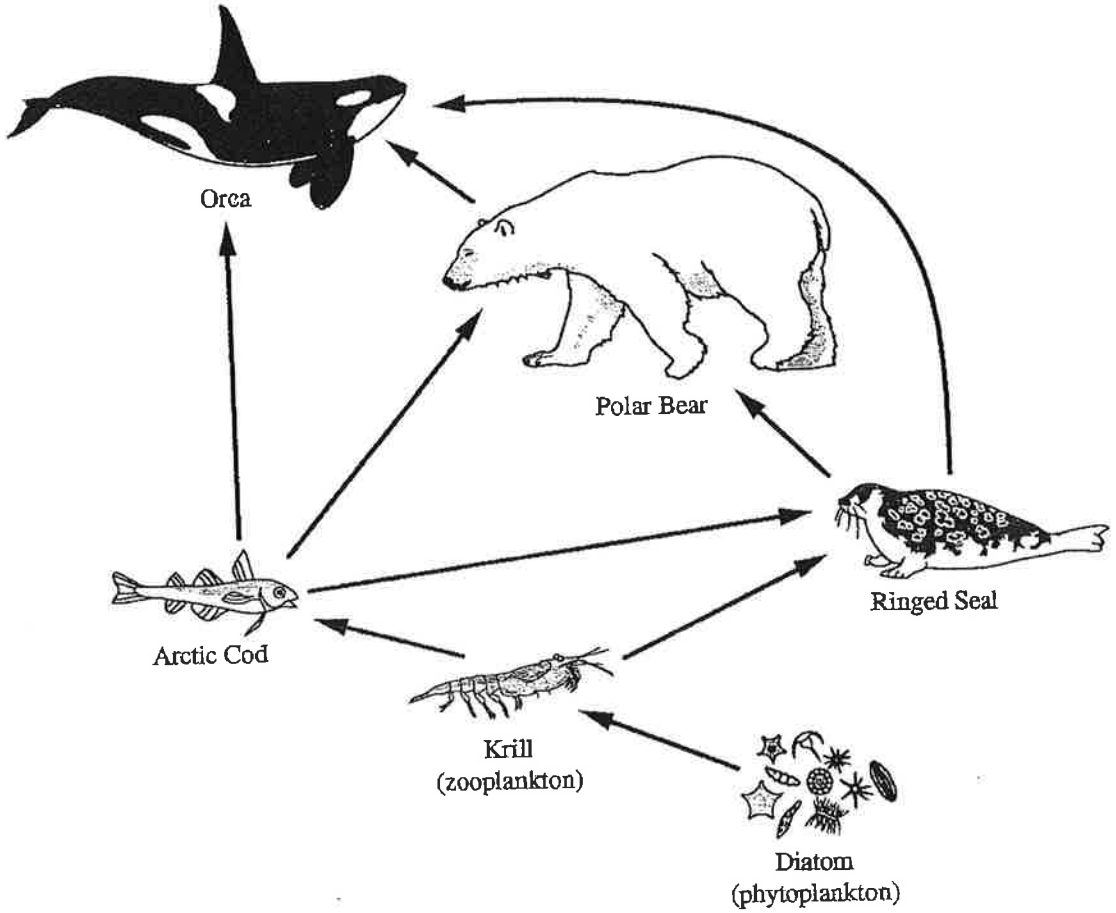
3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	Diatom (phytoplankton)
(ii) **Identify** a primary consumer	Krill (zooplankton)
(iii) **Identify** a secondary consumer	Arctic cod

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

b. The direction of the arrows in the diagram represents the movement of energy.

C. The change in sea ice is affecting the polar bears' ability to hunt and feed by reducing the area where it can find its preferred prey.

d. melting sea ice leads to a feedback loop that increases Artic warming by raising sea levels. The raised sealevel will cover more ice, which will make it melt.

ei. One reason a species may migrate along distance is to move to a breeding ground.

eii. One commercial Activity that could lead to the death of right whales is boating. large commercial boats and cruises may hit whales, when riding through the ocean. Big commercial boats have large propellers that could harm whales.

eiii. One strategy that could be implemented to decrease right whale deaths is to be aware

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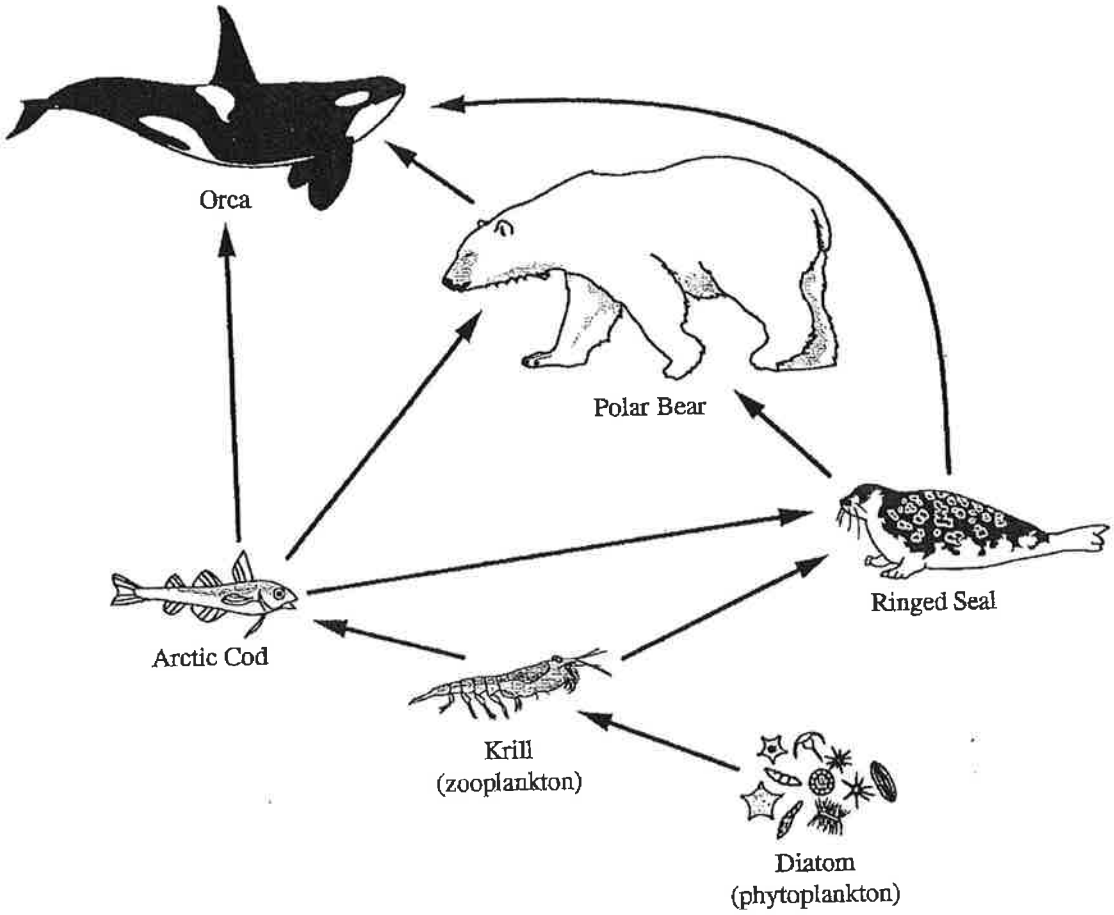
ADDITIONAL PAGE FOR ANSWERING QUESTION 3

of migratory routes and avoid them during migration season of the whales.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	phytoplankton
(ii) **Identify** a primary consumer	zooplankton
(iii) **Identify** a secondary consumer	ringed seal

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

ai. One primary producer is phytoplankton, or diatom.

aii. A primary consumer is zooplankton, or krill.

aiii. A secondary consumer is a ringed seal.

b. As one organism is consumed by another, energy is transferred to the consumer. The arrows in the diagram indicate energy flow up the food web. Those who feed at higher trophic levels need to consume more of their prey because only around 10% of the energy an organism has can be used by the organism feeding upon it.

c. Because there is no need for air holes for the seals (due to the large expanses of open ocean), polar bears cannot wait by the nonexisting holes for seals to come to the surface to breathe. Because of this, polar bears have a decreased ability to hunt and feed.

d. As sea ice melts, the water temperature increases due to melting ice. This warmer temperature makes more ice melt, which creates a positive feedback loop (it appears to increase indefinitely)

ei. One reason a species may migrate a long distance is because of seasonal temperature changes, which makes the species move to their ideal temperature zone.

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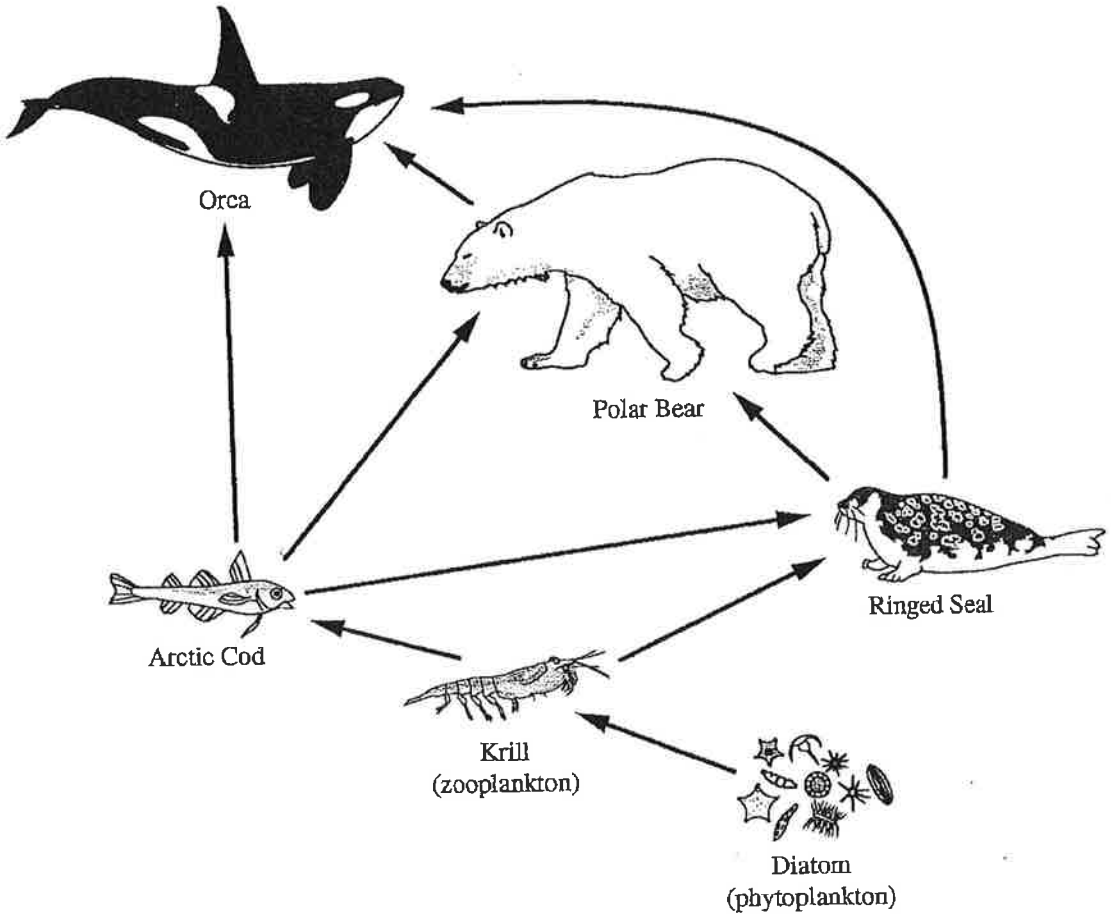
eii Overfishing, a human commercial activity due to Tragedy of the Commons, leads to the death of right whales because there is not enough prey (fish) for them to feed on.

eiii. One strategy to decrease right whale deaths from overfishing would be to put caps on the amount of fish brought in by each country. This would allow fish populations to regenerate, which provides more food for right whales and a population rebound.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	Diatom
(ii) **Identify** a primary consumer	krill
(iii) **Identify** a secondary consumer	Ringed seal

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(b) The direction of the arrows indicate the direction of the energy flow throughout the organisms in the food web.
(c) With the decreasing amount of sea ice, polar bears are put at a disadvantage when it comes to hunting and feeding on the Ringed seals. Since polar bears are not aquatic organisms, it makes it difficult to hunt and feed when there is less sea ice around.
(d) Melting sea ice would be considered as a positive feedback loop because it leads to Arctic warming. The Arctic warming could end up destroying habitats of animals such as polar bears, which could lead to a decline in species population.
(e)(i) One reason a species may migrate a long distance is because of climate purposes. For example, birds may migrate

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from the north to the south in winter months because of the warmer temperatures during winter in the south.

(ii) Water pollution could contribute to the death of right whales. For example, oil could be dispersed into the ocean which could severely affect aquatic life.

(iii) Restrictions could be placed on oil drilling and extraction in order to decrease the risk of oil spills. For example, there could be a law passed that would prohibit the abundance of oil drilling sites on water surfaces.

(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(a) i A primary producer is phytoplankton

ii A primary consumer is krill

iii A secondary consumer is the arctic cod

(b) The arrows in the diagram represent the order of the food chain. Whom is a prey to a predator.

(c) Due to the melting of the arctic sea, the seals have more opportunities in surviving making it more difficult to feed since polar bears are specialists.

(d) Melting ice leads to the rise of sealevel. While the level rises, ice submerges cause even more ice to melt.

(e) i Species migrate to warmer grounds to breed.

ii Humans pollute the ocean and fail to gather floating plastic.

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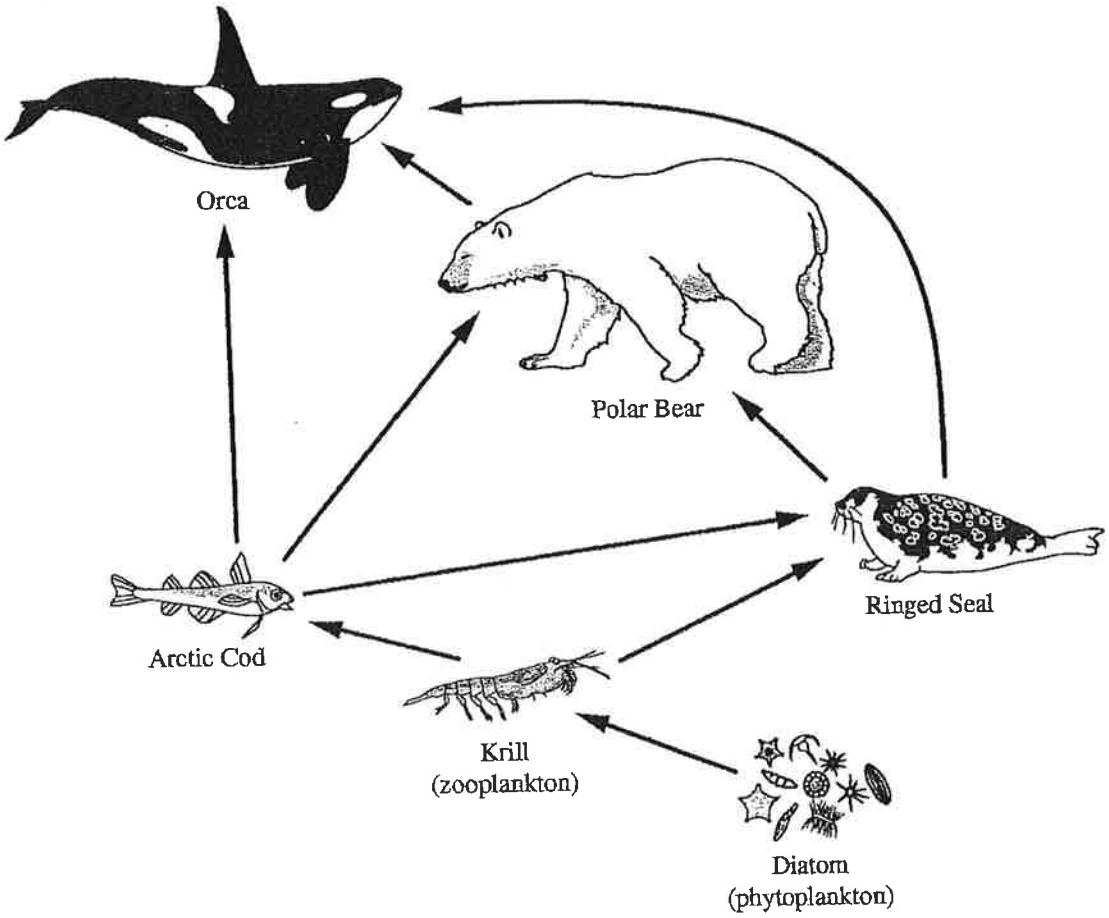
iii The floating plastic pollutants intervene and can be releasing chemicals into their tissues.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	diatom (phytoplankton)
(ii) **Identify** a primary consumer	ringed seal
(iii) **Identify** a secondary consumer	polar bear

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

3b) The direction of the arrows in the diagram indicate the ranking of the organisms, from primary producers to primary consumers.

3c.) Because of global warming, the sea ice melts, creating more water for polar bears to swim through. However, they have adapted to barely swim for food because of the ice. Now it is much harder for the polar bears to hunt for food, as they now have to swim greater distances and possibly drown.

3di) When the Sun gives off light onto the Earth, most of the radiation and heat is reflected off of the ice in the Arctic and back into the atmosphere. With the ice melting, less radiation and heat is reflected, causing more warming to occur in the Arctic.

3e) i) One reason a species may migrate a long distance is for survival. During specific seasons, some species may migrate because they can't survive in the specific temperature so, they migrate to an area with a temperature that they

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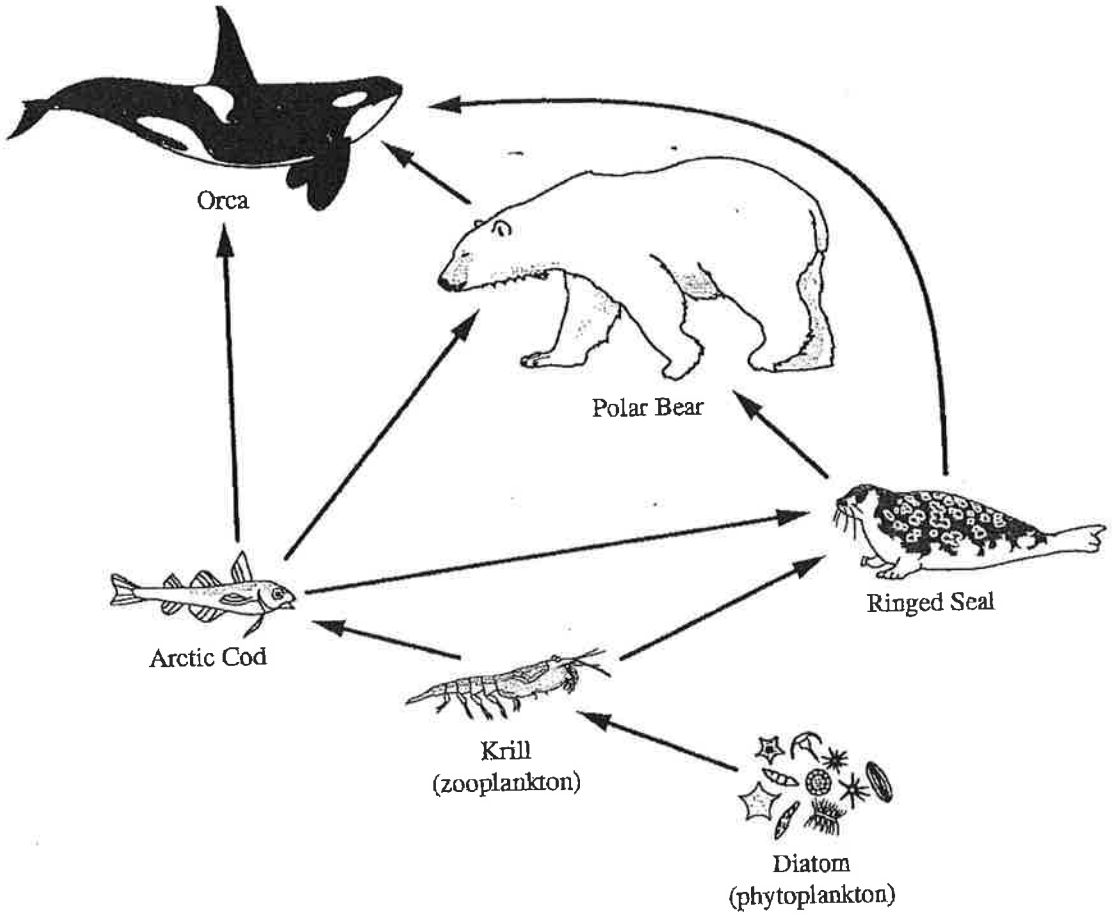
can survive in.

ii) A commercial activity that may result in the death of right whales is the transportation of oil. When an oil spill happens, it is very hard to clean and can kill many organisms that live in the ocean, even whales.

iii) A strategy that could reasonably be implemented to decrease right whale deaths is to have a much better design on transportation vehicles that move oil. With this implemented, there would be a much smaller chance of having an oil spill, therefore decreasing the amount of deaths of right whales.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	Arctic cod
(ii) **Identify** a primary consumer	Diatom (phytoplankton)
(iii) **Identify** a secondary consumer	Polar Bear

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(B)- The directions of the arrows indicate what the resources goes to, for example the Arctic Cod may be consumed by not only the Ringed Seal but also the Polar Bear and Orca. It is the indication of the prey for each animal.

(C)- The Ringed Seal goes to the holes in the ice to breathe, if there are no holes than they must adapt to be able to breathe in other ways, in which these ways the polar bears haven't adapted to causes the polar bear to have a lack of resources to prey on.

(D)- The melting of the sea ice is a result in Global warming and climate change. The ice melting causes sea levels to rise causing the feedback loop of temperatures to rise due to lack of ice keeping the climate under control.

(i)- A species may migrate to find food sources, if their prey are migrating it only makes sense for them to follow their food and move to a more ideal habitat.

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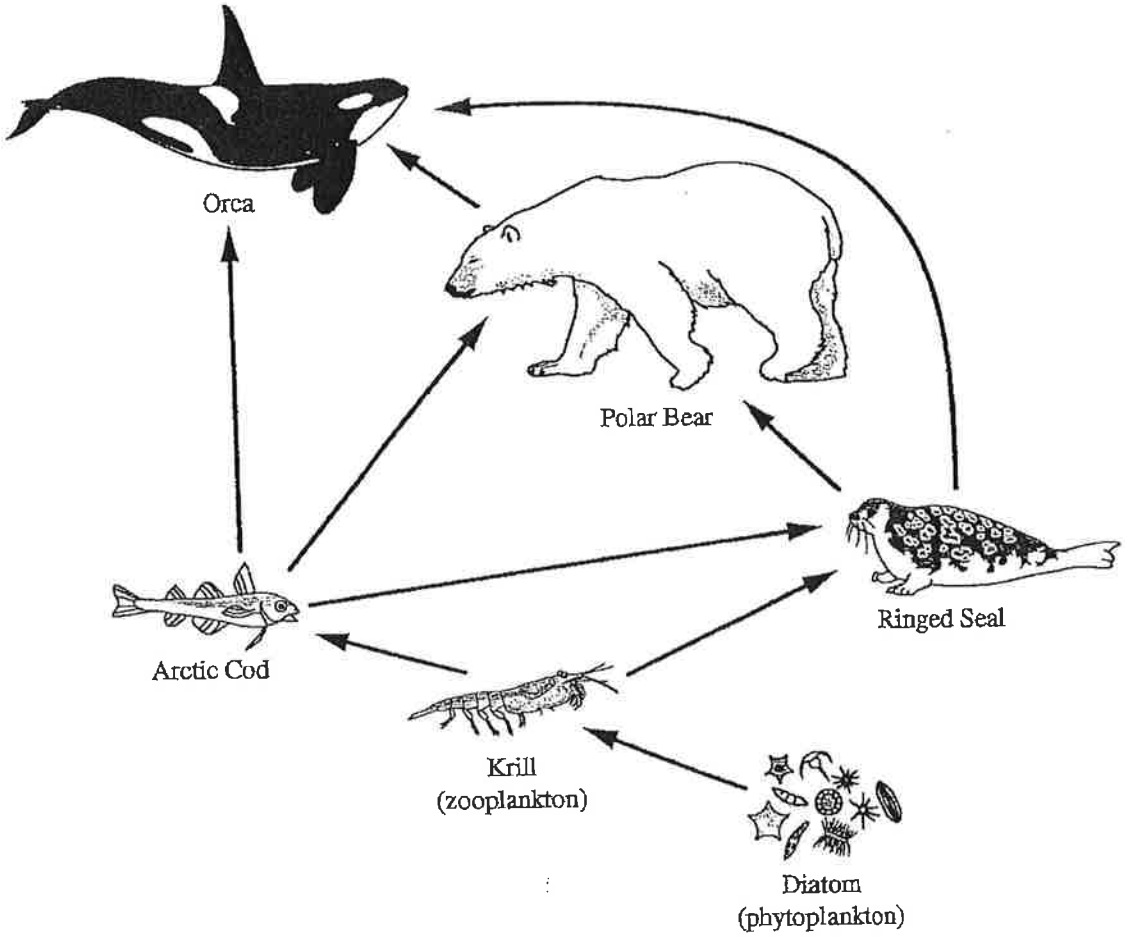
(ii) · A leading cause of death caused by human activities would be open net fishing. The whales may swim into these large fishing nets placed by humans and get caught and not being able to escape.

(iii) · Putting a ban on these fishing activities. Or highly monitoring the fisherman using the deadly nets. As well as cleaning the scraps of old netting out of our oceans.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) **Identify** a primary producer	Diatom
(ii) **Identify** a primary consumer	~~Orca~~ arctic cod
(iii) **Identify** a secondary consumer	polar bear

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

(c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

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(e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

(i) **Provide** one reason a species may migrate a long distance.

(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

b) What is indicated is what that organism is going to and what each one needs to eat to survive, otherwise all other animals won't have that specific organism ~~to~~ for them to eat.

c) Change in ice habitat makes it difficult for the polar bears to adapt. They have to adapt to the changes to be able to hunt and feed in order to survive.

d) This leads to a feedback loop that increases arctic warming because that means that temperatures are dropping, therefore causing the organisms living in that environment to adapt to the warm changes. to survive.

~~e)i~~

e i) A species may migrate a long distance in search of an adaptable environment in which they can survive. They might not have been getting their needs in one location, so they migrate in search of a place that does have it.

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ii) An activity that may result in the deaths of whales is pollution in the water and their environment that contributes negatively to their poor health.

iii) One strategy that can be used to help the problem is ~~being~~ enforcing that pollution not take place in order to ensure the safety of the whales.

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2018 AP ENVIRONMENTAL SCIENCE

Question 3

Sample Identifier: 3A
Score: 10

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying diatom. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying Arctic cod.
- 1 point was earned in part (b) for describing that the arrows indicate the "flow of energy."
- 1 point was earned in part (c) for describing that "the seals can breach the surface virtually anywhere which means the polar bears on the ice cannot attack them." The student indicates that "the polar bears also have a much smaller area to hunt in".
- 2 points were earned in part (d). 1 point was earned for "less ice is reflecting the sun's rays which leads to the warming of the water." 1 point was earned for "warming of the water which goes back to melting more sea ice." The student completes the positive feedback loop.
- 3 points were earned in part (e). 1 point was earned in (e)(i) for providing a reason to migrate "is to go where food is more plentiful." 1 point was earned in (e)(ii) for the description of the commercial activity of shipping which included "...if a whale breaches the surface in front of a ship, there is not anything to do to stop the ship from hitting it." 1 point was earned in (e)(iii) for "require those in operation of large commercial ships to have an awareness of right whale migratory patterns" as a strategy to be implemented to decrease right whale deaths.

Sample Identifier: 3B
Score: 9

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying diatom. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying ringed seal.
- 1 point was earned in part (b) for describing that the arrows indicate "the flow of energy."
- No points were earned in part (c).
- 2 points were earned in part (d). 1 point was earned for "sea ice reflects light and heat...oceans on the other hand absorb heat better than ice." 1 point was earned for "the ocean absorbs the heat instead...the increase in temperature melts more ice." The student completes the positive feedback loop.
- 3 points were earned in part (e). 1 point was earned in (e)(i) for "to reconvene with a partner to mate." 1 point was earned in (e)(ii) for "noise pollution from cargo ships" with later reference to engine noise that can disrupt the whales' sonar. 1 point was earned in (e)(iii) for "A common method to reduce engine noise is to create vibration proof hulls."

Sample Identifier: 3C
Score: 8

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying diatom. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying Arctic cod.
- 1 point was earned in part (b) for describing that the arrows indicate "The movement of energy."
- 1 point was earned in part (c) for describing that "seals can come up to breathe anywhere, making it hard for polar bears to identify the location of the seals and making it harder for them to get food."
- No points were earned in part (d).
- 3 points were earned in part (e). 1 point was earned in (e)(i) for "as a result of the changing of the seasons" with an example of birds flying south for the winter to find warmer temperatures. 1 point was earned for (e)(ii) for the description of "Large boats that are used for cruises...have sonar detectors...This can interfere with the whales [*sic*] own sonar system." 1 point was earned for (e)(iii) for "create laws that prevent the use of sonar activity during certain times of the year, such as when the whales are migrating."

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Sample Identifier: 3D
Score: 7

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying diatom. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying Arctic cod.
- 1 point was earned in part (b) for describing that the arrows indicate the "movement of energy."
- No points were earned in part (c).
- No points were earned in part (d).
- 3 points were earned in part (e). 1 point was earned in (e)(i) for providing the reason of "move to a breeding ground." 1 point was earned in (e)(ii) for describing "commercial boats and cruises may hit whales." 1 point was earned in (e)(iii) for describing that one strategy to reduce right whale deaths would "to be aware of migratory routes and avoid them during migration season of the whales."

Sample Identifier: 3E
Score: 6

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying phytoplankton. 1 point was earned in (a)(ii) for identifying zooplankton. 1 point was earned in (a)(iii) for identifying ringed seal.
- 1 point was earned in part (b) for describing that the arrows indicate "energy is transferred."
- 1 point was earned in part (c) for describing "large expanses of open ocean" and that "polar bears cannot wait by the nonexisting holes for the seals to come to the surface to breathe. Because of this, polar bears have a decreased ability to hunt and feed."
- No points were earned in part (d).
- 1 point was earned in part (e). 1 point was earned in (e)(i) for providing the reason "because of seasonal temperature changes, which makes the species move to their ideal temperature zone." No points were earned in (e)(ii) or in (e)(iii).

Sample Identifier: 3F
Score: 5

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying diatom. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying ringed seal.
- 1 point was earned in part (b) for describing that the arrows indicate "the direction of the energy flow."
- No point was earned in part (c).
- No point was earned in part (d).
- 1 point was earned in part (e). 1 point was earned in (e)(i) for providing the reason some birds migrate "because of the warmer temperatures during winter in the south." No points were earned in (e)(ii) or in (e)(iii).

Sample Identifier: 3G
Score: 4

- 3 points were earned in part (a). 1 point was earned in (a)(i) for identifying phytoplankton. 1 point was earned in (a)(ii) for identifying krill. 1 point was earned in (a)(iii) for identifying arctic [*sic*] cod.
- No point was earned in part (b).
- No point was earned in part (c).
- No points were earned in part (d).
- 1 point was earned in part (e). 1 point was earned in (e)(i) for providing the reason that a species may "migrate to warmer grounds to breed." No points were earned in part (e)(ii) or in part (e)(iii).

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Sample Identifier: 3H
Score: 3

- 1 point was earned in part (a). 1 point was earned in (a)(i) for identifying diatom.
- No point was earned in part (b).
- No point was earned in part (c).
- 1 point was earned in part (d) for "less radiation and heat is reflected causing more warming."
- 1 point was earned in part (e). 1 point was earned in (e)(i) for identifying that a species may migrate during "specific seasons" followed by "so, they migrate to an area with a temperature that they can survive in." No points were earned in part (e)(ii) or in part (e)(iii).

Sample Identifier: 3I
Score: 2

- No points were earned in part (a).
- No point was earned in part (b).
- No point was earned in part (c).
- No points were earned in part (d)
- 2 points were earned in part (e). 1 point was earned in (e)(i) for identifying that "there [*sic*] prey are migrating it only makes sense for them to follow." 1 point was earned in (e)(ii) for identifying that whales "may swim into these large fishing nets...and get caught." No points were earned in part (e)(iii) as a realistic strategy was not completely described.

Sample Identifier: 3J
Score: 1

- 1 point was earned in (a)(i) for identifying diatom.
- No point was earned in part (b).
- No points was earned in part (c).
- No points were earned in part (d).
- No points were earned in part (e).

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4. In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

   (a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

   (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

   (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

   (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

   In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

   (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

   In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

   - asbestos
   - radon
   - mold

   (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.

   (i) **Identify** a source for each indoor air pollutant.

   (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure

STOP

END OF EXAM

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Question 4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

(i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

(2 points; 1 point for each correct identification of an air pollutant released during burning of biomass)

(ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

(1 point for correct identification of a specific respiratory illness linked to identified pollutant)

Identification of TWO air pollutants	Identification of a specific human respiratory illness linked to identified pollutant
• Carbon monoxide (CO)	• CO poisoning
• Particulate matter (PM)	• Asthma • Chronic obstructive pulmonary disease (COPD) • Emphysema • Bronchitis • Lung cancer
• Nitrogen oxides (NOx)	• Pneumonia • Asthma
• Sulfur oxides (SOx)	• Bronchitis • Emphysema • Asthma
• Trace metals such as lead, mercury, arsenic and cadmium	• Bronchitis
• Methane (CH4)	• Bronchitis
• Volatile organic compounds (VOCs)	• Bronchitis • Asthma

(b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

(2 points; 1 point for correct identification of a realistic approach to reducing the impact and one point for correct description of reduction of illness linked to identified approach)

Identify one realistic approach	**Describe** how this approach would reduce incidence of respiratory illness
Ventilate through structural change (chimney construction, opening windows and doors)	Removes some or all of the air pollution from indoors/transfers pollutants out of the home, leading to less respiratory illness
Switch to cleaner-burning/more efficient cooking stove	Requires less fuel to be burned releasing fewer air pollutants into the home, leading to less respiratory illness
Switch to a different energy source (solar, natural gas, biogas, electric)	Produces less or no indoor air pollutants, leading to less respiratory illness
Cook outdoors	Move the source of the air pollutant outside/leads to less or no concentrated air pollution inside, leading to less respiratory illness

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In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

(c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

(1 point for correct discussion of why children under the age of five are at a greater risk)

- Children have an underdeveloped or less-developed immune systems leading to a greater risk of illness following exposure
- Children have a lower body mass leading to a higher relative dose of air pollution
- Children spend more time indoors leading to higher exposure to air pollution
- Children have smaller respiratory systems (narrow airways) so mild inflammation may cause more severe respiratory distress

In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

(d) Choose TWO of the three common indoor air pollutants (asbestos, radon or mold) listed above and complete the following table.

(i) **Identify** a source for each indoor air pollutant

(2 points; 1 point for correct identification of a source of each indoor air pollutant chosen)

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

(2 points; 1 point for correct description of method of reduction for each indoor air pollutant chosen.)

	Identification of a source	Description of a method for reducing exposure
Asbestos	• Building materials (cement, floor tiles, ceiling panels, drywall, popcorn ceiling) • Insulation • Naturally occurring in soil and rocks in a dirt-floor basement or crawl-space	• Safely remove asbestos-containing materials/abatement • Encapsulate/cover and seal materials/construct temporary enclosure • Leave undisturbed
Radon	• Soil, rocks, Earth's crust • Gas from uranium containing rocks • Gas penetrates foundation	• Seal floors, walls and joints • Install structural exhaust venting • Install sub-floor depressurizing system
Mold	• Water from flooding, natural disasters or leaks • Poorly vented or maintained damp environments	• Replace or repair damaged surfaces/structures • Clean and/or disinfect affected areas • Dehumidify or ventilate inside air • Improve drainage (from roof or yard, sump pump the basement)

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4. In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

   (a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

   (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

   (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

   (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

   In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

   (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

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   - radon
   - mold

The Mitochondria is the power house of the cell

   (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.

   (i) **Identify** a source for each indoor air pollutant.

   (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
radon	radioactive materials decaying in rock surrounding the home	Seal completely the home's basement to ark any infiltration of radon gas from the bedrock.
asbestos	Insulation material that is decades old containing microscopic glass shards	Replace any asbestos producing insulation immediately and safely to avoid mesothelioma

A)i) Two pollutants released during the burning of biomass indoors include carbon monoxide and particulate matter like ash

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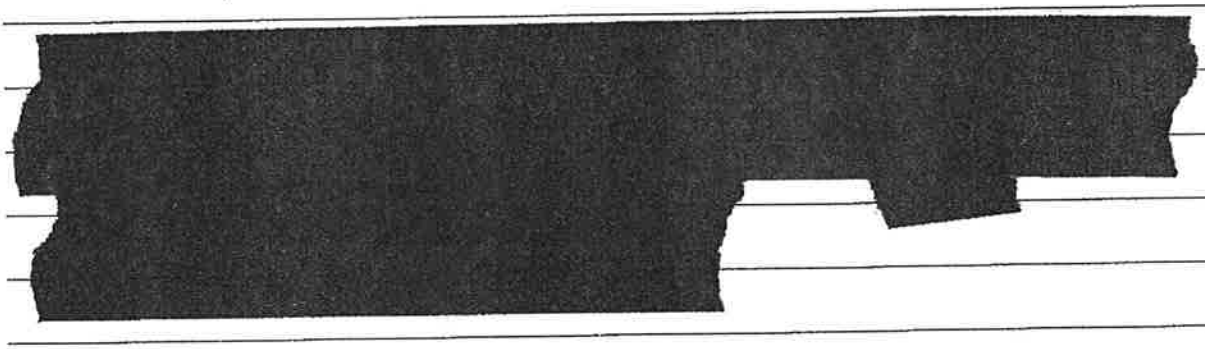
b) A person may develop Asthma from continuous exposure to particulate matter like ash.

b) Proper ventilation techniques like chimneys are necessary. Biomass combustion under a chimney will allow the particulate matter to rise and leave the house.

c) Children under the age of 5 have smaller masses than adults. This means that it takes less of a dose of an indoor air pollutant to harm their health than an adult. The concentration of pollutants in a child's body accumulates quicker leading to a greater risk of illness



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(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
Radon	a naturally occuring gas from the decay of uranium within the Earth.	Increase ventilation in the basements or ground levels because radon is a heavy gas and settles down lower.
Asbestos	insulation	Wear proper equipment (respirators) when handeling or allow proper authorities to remove it.

(a)(i) particulate matter (PM) and carbon monoxide (CO)

(ii) ~~Carbon monoxide inhalation allows the CO to bind with blood instead of oxygen~~ Particulate matter can cause and worsen Asthma and its symptoms.

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(b) Allowing more ventilation when burning biomass will reduce the concentrations of the air pollutants within the dwelling and by allowing clean air from outside to enter.

(c) Children still have developing lungs under the age of five, this makes particulate matter more lethal because it can reach the lower lung regions with more ease.

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(d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.

(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
radon	decaying uranium	have proper ventilation, allow air flow, fill cracks in foundation
asbestos	insulation	use other forms of insulation, have proper ventilation

a) i) Carbon dioxide & particulate matter are two air pollutants released during the burning of biomass.

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ii) Asthma can be a result of particulate matter making its way into your lungs.

b) Installing a chimney. This allows the biproducts of the combustion to be in one area & be ventilated out instead of trapped in the house & breathed.

c) Children under the age of five are smaller so they will not be able to withstand the dosage an adult would.

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Indoor Air Pollutant	Source	Method for Reducing Exposure

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Ai) One air pollutant released would be VOC's into the environment, while another would be particulate matter indoors.

Aii) Particulate Matter can cause Asthama due to the blocked and irritated airways.

B) One approach is ~~to create~~ to switch to a gas stove, ~~that is~~ This in turn would keep particulate matter from being released into the environment for people to breath in, resulting in a reduced incidences of respirory illnesses caused by particulate matter.

C) Children under the age of 5 have not yet ~~had~~ fully matured their immune systems, which in turn makes it harder to fight off diseases and pollutants making them more ~~susceptible~~ ~~sceeptible~~ exposed.

Di) One source of Asbestos is ~~the of~~ old insulation in buildings while one source of mold is ~~moist~~ due to condensed water exposed to heat and air.

Dii) One way to reduce Asbestos exposure is to replace old insulation with new insulation that does not contain Asbestos. One way to reduce exposure to mold is to let any moist surface

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dry completely reducing amount of mold that will form, and reducing exposure.

STOP

END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX ON THE FRONT COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

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(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
asbestos	common in older buildings and [redacted] areas like flooring	[redacted] redo/renovate/cover any contaminated flooring or other building areas
mold	outside contaminants that have [redacted] optimal growing conditions inside	better circulation of any building/house or completely remove the contaminated area

One air pollutant released during the burning of biomass is particulate matter from the biomass. Another possible air pollutant is carbon dioxide. One respiratory illness that can be

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caused by particulate matter is emphysema, which is when the particulates inhaled by a person builds up in the lungs.

One approach that could be used to reduce the impact of biomass combustion indoors is to develop other sources of renewable energy. For example, photovoltaic cells can be used to obtain solar energy and convert it into useful electrical energy that can be used indoors. This would reduce respiratory illness because the use of cleaner energy like solar energy prevents the burning of biomass, which prevents the release of pollutants like carbon dioxide and particulate matter.

One reason children are at a greater risk for illnesses is because the dose-response relationship measures the effects of toxic air pollutants in mg/kg. Children have a smaller body mass, which means that fewer air pollutants are necessary to cause illness and even death.

3:42

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(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
mold	Bacterial growth as a result of moist conditions	Ventilation systems in parts of house prone to mold growth, such as the bathroom.
radon	Old insulation in walls.	Have old insulation repiaced.

ai) methane and particulate matter.

aii) particulate matter may cause bronchitis.

b) Require that ventilation be utilized when

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burning biomass to reduce the likelihood that humans inhale large amounts of household air pollutants.

c) Children under the age of five have smaller lungs than adults, leading them to be more prone to infection.

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(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
asbestos	paint, old walls	Reduce and fix old houses, make them sturdier and with healthy walls...?
mold	water damaged / wet, moist, humid walls	use vinegar to help kill the mold (or bleach) replace the walls for non-mold infested ones reduce water introduction.

a) i) Two air pollutants released during the burning of biomass are carbon dioxide and particulates.

ii) A human respitory illness related to particulates →

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lung irritation
is [illegible]. the particulates can irritate the lungs.

b) A realistic approach to the reduction of the impact of biomass combustion indoors would be to put a filter on anything that would house burning biomass. This would reduce the amount of particulates that you would breathe in reducing your chance of lung irritation.

c) One reason children under the age of 5 are at a greater risk is that they don't have as developed lungs and bodies so they can get sick easier and their body isn't strong enough to stop it from killing them.

d) on the chart

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(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
[redacted] asbestos	particles being brought into your house from outside.	• take off shoes before coming inside.
radon	radiation from technology	• use less technology with radioactivity.

a.) Carbon Monoxide and ~~Nuclear energy~~ NO_x are released when cooking and heating.

ii) NO_x can release into the air and

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have effects like asthma. b) Using renewable energy helps by not using nuclear or coal to provide heat. Its more natural. c) As kids grow so are their bodies, cells, and systems. Exposure to things that their body can't handle comes with depth.

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(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
Mold	Bacteria growing in humid and enclose & areas.	Increase ventilation in homes and annual inspection of homes.
Radon	Electrical devices such as phones, television	Unplug devices when not being used

A.) i) One air pollutant released during the burning of biomass is methane. Another air pollutant that can be released

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are greenhouse gases caused by the carbon emissions. Also VOCs can be emitted.

ii.) The pollutants can cause asthma because of the accumulation of smog in the air, especially during the warmer seasons

B.) One approach is to only have the burning of biomass during certain times of day. This would allow for restricted burning of biomass, which would result in less smog that causes asthma.

C.) Children under 5 years old are at greater risk than adults because their lungs and other key organs like kidneys aren't fully developed, so their bodies can't handle harsh pollutants.

D.) On table

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In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

(d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.

(i) **Identify** a source for each indoor air pollutant.

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
Radon	from heaters in basements	Use another way to heat up house or have check-ups for Radon levels.
Mold	exposed areas of bacteria.	Clean house up and make sure you don't have these exposed areas.

2.) i. Two indoor air pollutants that are released during the burning of biomass indoors for cooking and heating are radon and carbon monoxide.

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ii. One respiratory illness that one of these aire pollutants may cause is asthma or problem breathing.

b.) One approach we can go at would be to require everyone to have their home's inspected annually to make sure the levels of these pollutants don't get past a ~~certain~~ certain level. This will help ~~with~~ reduce the incidence of respiratory illness because with reduced levels of these pollutants, people will have less chances of getting exposed to them.

C.) Children under the age of five are at greater risk than adults because their bodies aren't even close to fully developed and they've been exposed to much less of these pollutants ~~in~~ in their lifetime, than adults have.

~~Best~~

AP® SAMPLE STUDENT RESPONSES AND SCORING NOTES
2018 AP ENVIRONMENTAL SCIENCE

Question 4

Sample Identifier: 4A
Score: 10

- 3 points were earned in part (a). 2 points were earned in a(i) for identifying "carbon monoxide" and "particulate matter" as indoor air pollutants that result from burning biomass. 1 point was earned in a(ii) for identifying that particulate matter can cause asthma.
- 2 points were earned in part (b). 1 point was earned for identifying that "ventilation techniques like chimneys" can be used to reduce the impact of biomass burning indoors. 1 point was earned for describing that chimneys "allow the particulate matter to rise and leave the house" reducing the exposure to the pollutant.
- 1 point was earned in part (c) for discussing that "children smaller masses than adults" and "This means it takes less of a dose...to harm their health."
- 4 points were earned in part (d). 2 points were earned in (d)(i). 1 point was earned for identifying the source of radon as "radioactive materials in rock" and 1 point was earned for identifying that old insulation is a source of asbestos. 2 points were earned in part d(ii). 1 point was earned for describing that exposure to radon could be reduced by completely sealing the basement of the house and 1 point was earned for describing that to "replace any asbestos producing insulation immediately and safely" is a method to reduce exposure.

Sample Identifier: 4B
Score: 9

- 3 points were earned in part (a). 2 points were earned in (a)(i) for identifying " particulate matter and carbon monoxide" as indoor air pollutants that result from burning biomass. 1 point was earned in a(ii) for identifying that particulate matter can cause asthma.
- 2 points were earned in part (b) for identifying and describing that "allowing more ventilation when burning biomass will reduce concentrations of air pollutants within the dwelling and by allowing clean air from the outside to enter" will reduce the incidence of respiratory disease.
- No point was earned in part (c).
- 4 points were earned in part d. 2 point were earned in (d)(i). 1 point was earned for identifying that radon is "a naturally occurring gas from the decay of uranium within the Earth" and 1 point was earned for identifying that asbestos is found in "insulation". 2 points were earned in part d(ii). 1 point was earned for describing that to "increase ventilation in basements" would reduce radon exposure and 1 point was earned for describing that to "wear proper equipment (respirators) when handling or allow proper authorities to remove it" would reduce exposure to asbestos.

Sample Identifier: 4C
Score: 8

- 2 points were earned in part (a). 1 point was earned in (a)(i) for identifying particulate matter as an indoor air pollutant that results from burning biomass. No point was earned for carbon dioxide because it is not an indoor air pollutant. 1 point was earned in a(ii) for identifying that "asthma can be a result of particulate matter."
- 2 points were earned in part (b). 1 point was earned for identifying "installing a chimney" as an approach to reducing the impact of biomass burning and 1 point was earned for describing that "This allows the byproducts of combustion to be...ventilated out instead of trapped in the house and breathed."
- 1 point was earned in part (c) for discussing that "children under the age of five are smaller so they will not be able to withstand the dosage an adult would."
- 3 points were earned in part d. 2 points were earned in (d)(i), 1 point was earned for identifying "decaying uranium" as a source of radon and one point was earned for identifying insulation as a source of asbestos. 1 point was earned in d(ii) for describing "have proper ventilation, allows air flow" as a method to reduce exposure to radon.

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Sample Identifier: 4D
Score: 7

- 3 points were earned in part a. 2 points were earned in (a)(i) for identifying VOCs and particulate matter as indoor air pollutants that result from burning biomass. 1 point was earned in a(ii) for identifying that particulate matter can cause asthma.
- 2 points were earned in part (b) for identifying that to "switch to gas stove...would keep particulate matter from being released into the environment for people to breath [*sic*] in, resulting in reduced incidences of respiratory illnesses."
- 1 point was earned in part (c) for discussing that "children under the age of five have not yet fully matured their immune systems, which makes it harder to fight off diseases."
- 1 point was earned in (d)(i) for identifying "old insulation in buildings" as a source of asbestos. No points were earned in part d(ii) because replacement of insulation must be specifically described as being done safely or professionally.

Sample Identifier: 4E
Score: 6

- 2 points were earned in part (a). 1 point was earned in (a)(i) for identifying particulate matter as an indoor air pollutant that results from burning biomass. 1 point was earned in (a)(ii) as particulate matter can cause emphysema.
- 2 points were earned in part (b) for identifying that "photovoltaic cells can be used to obtain solar energy" and for describing that "the use of cleaner energy like solar energy prevents the burning of biomass, which prevents the release of pollutants like...particulate matter."
- 1 point was earned in part (c) for discussing that "the dose-response relationship" is important and "children have a smaller body mass, which means that fewer air pollutants are necessary to cause illness."
- 1 point was earned in part d(i) for identifying "older buildings and areas like flooring" as a source of asbestos. No points were earned in part d(ii).

Sample Identifier: 4F
Score: 5

- 3 points were earned in part (a). 2 points were earned in (a)(i) for identifying methane and particulate matter as indoor air pollutants that result from burning biomass. 1 point was earned in a(ii) for identifying that "particulate matter may cause bronchitis."
- 1 point was earned in part (b) for identifying ventilation as a realistic approach to reduce the impact of biomass combustion indoors.
- No points were earned in part (c).
- 1 point was earned in part (d). No points were earned in (d)(i). 1 point was earned in (d)(ii) for describing that "ventilation systems in parts of the house prone to mold growth" will reduce exposure to mold.

Sample Identifier: 4G
Score: 4

- 1 point was earned in (a)(i) for identifying "particulates" as an indoor air pollutant that results from burning biomass. No points were earned in (a)(ii) because lung irritation is not a respiratory illness.
- No points were earned in part (b) as filtering is not a realistic approach.
- No point was earned in part (c).
- 3 points were earned in part (d). 2 points were earned in (d)(i) for identifying that "paint" as a source of asbestos and "water damaged...walls"" are a source of mold. 1 point was earned in d(ii) for describing that vinegar or bleach can help kill mold.

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Sample Identifier: 4H
Score: 3

- 3 points were earned in part (a). 2 points were earned in (a)(i) for identifying "Carbon monoxide and NO_x" as indoor air pollutants that result from burning biomass. 1 point was earned in a(ii) for identifying that "NO_x can release into the air and have effects like asthma."
- No points were earned in part (b) as "renewable energy" is too vague.
- No points were earned in part (c).
- No points were earned in part (d).

Sample Identifier: 4I
Score: 2

- 1 point was earned in a(i) for identifying methane as an indoor air pollutant that results from burning biomass. No point was earned in (a)(ii).
- No points were earned in part (b) as burning biomass during different parts of the day would not reduce the total amount of pollutants produced.
- No point was earned in part (c).
- 1 point was earned in part (d). No points were earned in (d)(i). 1 point was earned in (d)(ii) for describing "increased ventilation" as a means of reducing exposure to mold.

Sample Identifier: 4J
Score: 1

- 1 point was earned in (a)(i) for identifying carbon monoxide as an indoor air pollutant that results from burning biomass. No point was earned in (a)(ii).
- No points were earned in part (b).
- No point was earned in part (c).
- No points were earned in part (d).

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